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SURGICAL ASPECTS OF ACUTE ABDOMINAL DISEASE IN INFANCY AND IN CHILDHOOD

CHARLES W. McLAUGHLIN JR., M.D.
AND
HERBERT H. DAVIS, M.D.
OMAHA

Few medical problems offer greater difficulties than early, accurate diagnosis and correct treatment of the acute abdominal diseases of infants and children. Because of the treacherous behavior of these diseases, the general surgeon who observes relatively few of the children suffering from them is at especial disadvantage. The purpose of this paper is to present our surgical experience with a series of patients varying in age from birth to 12 years, together with a review of the recent literature.

It has generally been recognized that surgical treatment of infants and children must differ greatly from surgical treatment of adults. In patients under the age of 12 years the unstable metabolism influences markedly the reaction to acute peritoneal lesions. Requirements of food and fluid are more constant in children than in adults because of growth and its demands on the tissues; temporary interruption of these supplies is detrimental and may in a short time become serious. Rapid and dangerous loss of essential body fluid quickly results from such common symptoms of acute abdominal disease as vomiting and diarrhea. This alteration of the fluid balance, which develops rapidly into acidosis in all acute abdominal emergencies, cannot be too strongly emphasized. Prompt and complete restoration of fluid balance is necessary for successful treatment. The administration of dextrose and saline solution by vein or of saline solution by subcutaneous injection often permits a seemingly hopeless condition to be treated successfully by surgical intervention. In cases of excessive and protracted loss of fluid, we prefer lactate-Ringer solution (as devised by Hartman). In our opinion the subcutaneous use of dextrose even in weak concentrations is never justified, being associated with increased pain and appreciable risk of serious infection in the soft tissues. If dextrose is indicated, venoclysis should be used.

Unlike the great majority of such conditions in adults, acute abdominal emergencies in infants and children cannot be diagnosed from the

history alone. The observer, not the patient, furnishes most of the history; a description of early and prodromal symptoms can rarely be obtained, and all too frequently the condition is far advanced when advice is sought. An evaluation of the physical findings, therefore, is of great importance. Abdominal pain, usually the primary symptom, must be differentiated according to its origin, whether visceral or peritoneal. Edwards [1] listed the principal characteristics of each type, and, though his classification is not absolute, it is of great assistance.

Peritoneal	Visceral
Localized	Diffuse
Constant	Intermittent
Reflex rigidity of abdominal wall muscle	No rigidity of abdominal wall muscle
Elevated temperature	Normal or subnormal temperatures

Visceral pain, extremely common in childhood and usually the most prominent symptom, associated with little or no localizing tenderness, tends to improve promptly with expectant treatment. Stephens [2] observed that colicky pain is eased by pressure, whereas pain from inflammation is increased by pressure. In infancy, however, visceral pain may be of serious import if accompanied by other definite findings, as in cases of intussusception.

Peritoneal pain must always be considered of serious import, since it is evidence of an inflammatory process within the peritoneal cavity. The examiner's problem is to determine the presence of real localized tenderness with associated muscle guard or rigidity.

It is well recognized that the threshold of the nervous system for pain varies markedly in different persons. As a group, infants and, to a lesser degree, children react to pain differently from the average adult. Apfel [3] pointed out that the average child, probably because of underdevelopment of the nervous system, is much less disturbed than is the adult by the pain of acute abdominal disease. Very young children rarely show abdominal rigidity in acute visceral pathologic conditions but do show distention. The infant usually evidences pain by frequent crying out and flexing the thighs on the abdomen. Tenderness can usually be demonstrated if the lesion is inflammatory. In the very young, in the absence of pathologic change in the throat, chest or kidneys, local abdominal tenderness accompanied by nausea and vomiting indicates intraperitoneal inflammatory disease.

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1. Edwards, H. C.: Surgical Emergencies in Children, New York, William Wood & Company, 1936, p. 95. Morley, J., cited by Edwards.

2. Stephens, H. D.: The Acute Abdomen in Infancy and Childhood, M. J. Australia **1**:465, 1938.

3. Apfel, H.: Significance of Abdominal Pain in Children in Light of Recent Studies, Arch. Pediat. **47**:17, 1930.

Abdominal examination is often difficult because of the child's reaction. Fraser [4] recommended the use of very light anesthesia for certain children, especially if intussusception is suspected, to facilitate careful palpation and accurate diagnosis. We have not used this method, but it is worthy of consideration. Certainly warm hands and gentleness win the young patient's confidence and aid in obtaining the necessary information.

Acute appendicitis is the one acute abdominal lesion common to all age groups. For all practical purposes the common lesions of adult life with the exception of appendicitis may be excluded, and in their stead a different array of conditions must be considered.

In table 1 reports of nine large series of admissions to children's hospitals for acute conditions of the abdomen are anlyzed. This compilation strikingly illustrates the limited number of types of pathologic processes responsible for the disease in the vast majority of cases. Appendicitis, as in adult groups, is the most frequent pathologic lesion, being present in from 40 to 90 per cent of the reported cases. Intussusception is second, followed closely by streptococcic and pneumococcic peritonitis. The rest of the series, less than 10 per cent, shows a wide variety of conditions infrequently encountered. Although the great variety of developmental anomalies observed is worthy of emphasis, such anomalies are omitted because of their relatively small number. Discussion in this paper is limited to differential diagnosis and treatment of the four conditions listed as comprising over 90 per cent of acute abdominal diseases in children.

We are reporting on a series of 89 children under the age of 13 years admitted to the hospital for acute abdominal disease and observed during the last five years. In this series acute appendicitis was present in 62.9 per cent, intussusception in 4.4 per cent and streptococcic and pneumococcic peritonitis in 3.3 per cent. In the remaining 29.4 per cent a wide variety of other acute abdominal conditions occurred.

APPENDICITIS

Age Incidence and Mortality.—In all age groups appendicitis is the condition most commonly encountered in such acute cases, constituting from 50 to 90 per cent of all acute conditions of the abdomen requiring operation in children from birth to the age of 13 years. Although it is encountered with increasing frequency after the age of 5 years, it occurs in a sufficient number of younger children (with a distressingly high mortality) to warrant discussion of the subject with regard to both age groups.

4. Fraser, J.: (*a*) Appendicitis in Childhood, New York, William Wood & Company, 1926, vol. 2, p. 823; (*b*) Some Aspects of the Abdominal Emergencies in Childhood, Edinburgh M. J. **1**:173, 1922.

TABLE 1.—*Admissions of Children with Acute Abdominal Disease (Ages 1 to 12 Years)*

Author	Year	Total Cases	Acute Appendicitis		Intussusception		Intestinal Obstruction		Congenital Abnormalities		Streptococcic or Pneumococcic Peritonitis		Tuberculous Peritonitis		Pyloric Stenosis		Miscellaneous	
			Cases	Mortality	Cases	Mortality	Cases	Mortality	Cases	Mortality	Cases	Mortality	Cases	Mortality	Cases	Mortality	Cases	Mortality
Litchfield, H. R., and Denbo, L. H.: Acute Abdominal Conditions in Children, Illinois M. J. 63 : 222, 1933	1921	206	124 60.1%	25%	11 5.3%	....	...	....	...	....	...	....	12 5.8%	....	...	....	59 28%	....
Lanman [23]	1921	543	223 40.1%	13%	72 13.2%	41%	20 3.6%	50%	...	....	16 2.9%	75%	49 9%	34%	66 12.1%	9.9%	44 8%	....
Beekman [5]	1925*	330	316 90%	30%	...	....	...	....	...	....	12 3.6%	65%+	...	....	...	....	2 0.6%	....
Cohen [6]	1927	400	327 82%	4%	22 5.5%	22.7%	35 8.7%	....	...	...	10 2.5%	80%	...	....	...	....	29 7%	....
Horgan and Horgan [16]	1929	319	236 74%	8.4%	13 4%	30.7%	12 3.7%	33.3%	8 2.5%	75%	...	....	6 1.8%	33.3%	32 10%	22%	10 3.1%	30%
Portis, B.: Acute Surgical Abdominal Conditions in Children, Illinois M. J. 63 : 222, 1933	1933	158	145 92%	....	6 3.7%	0%	...	....	...	....	5 3.1%	....	2 1.2%	....	...	....	...	....
Hudson [10]	1934	1,107	717 65%	....	90 8.1%	....	62 5.6%	....	30 2.7%	....	29 2.6%	....	...	....	181 16.4%	....	...	....
Barrington-Ward [24]	1936	287	42%	....	37.6%	....	7.7%	....	...	....	7.7%	....	...	....	...	....	8%	....
Stephens [2]	1938	1,002	769 76.5%	4.4%	144 14.5%	12.5%	67 6.7%	41.8%	...	....	...	....	...	....	...	....	2.5%	....
McLaughlin and Davis (this paper)	1939	89	56 62.9%	8.9%	4 4.4%	25%	2 2.2%	0%	...	....	3 3.3%	0%	1 1.1%	0%	13 14.3%	7.5%	10 11%	0%

* All inflammatory lesions.

Appendicitis, rare in children under the age of 2 years, occurs in a rapidly increasing proportion of those above this age. Ladd [5] reported that 34 per cent of 200 patients were under the age of 6 years; Cohen,[6] that 19 per cent of 312 patients were under the age of 5 years; Christopher [7] observed the condition in 30 children under the age of 5 years, and Beekman [8] noted that 14 per cent of his 280 patients were in the age group from birth to 6 years. In the last-mentioned age group Ladd [5] reported a mortality of 19 per cent, Beekman [8] 25 per cent and Christopher [7] 30 per cent. In our own series only 3 patients, or 5.3 per cent, were under 6 years of age; all had spreading or general peritonitis when seen, and the mortality was 66.6 per cent.

The reasons for these high mortality figures may be considered under two headings: (1) the difficulty of diagnosis and (2) the rapidity of the process, due to anatomic and physiologic factors peculiar to this age group.

Difficulty of Diagnosis.—The usual difficulties of diagnosis are increased by the fact that the physical findings are much less distinct than in the older child. Hartshorn [9] stated that acute abdominal pain and tenderness localized in the region of the appendix in a child should be classified in every instance as appendicitis until the diagnosis is absolutely ruled out by the development of the process or by the presence of a primary focus elsewhere. Christopher [7] stated that in the group of children under the age of 6 years diagnosis is best made on the following points, in the order given: (1) tenderness in the right lower quadrant; (2) leukocytosis; (3) rigidity in the right lower quadrant, and (4) abdominal pain. The evaluation of pain and tenderness in these children is always difficult, however, and rigidity is usually lacking or occurs late.

Hudson [10] called attention to the fallacy of the old statement that a "child with abdominal disease is said not to sleep or let any one else sleep." Even with findings typical of acute abdominal disease, these patients may go to sleep and have to be awakened for examination. No group of patients becomes ill more quickly, yet with acute abdominal

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5. Ladd, W. E.: The Acute Surgical Abdomen in Children, Pennsylvania M. J. **34**:153, 1930.

6. Cohen, M.: Acute Surgical Diseases of the Abdomen in Children, Surg., Gynec. & Obst. **45**:595, 1927.

7. Christopher, F.: Appendicitis in Children Under Five Years of Age, Am. J. Dis. Child. **31**:525 (April) 1926.

8. Beekman, F.: Acute Inflammatory Diseases of the Abdomen in Children, Arch. Pediat. **2**:782, 1925.

9. Hartshorn, W. E.: Surgical Significance of Abdominal Pain in Children, M. Rec. **93**:96, 1918.

10. Hudson, H. W. Jr.: Abdominal Emergencies in Infancy and Childhood, Rhode Island M. J. **17**:18, 1934.

disease the picture is often confusing. Hughes [13b] has wisely stated, "The child is never too sick to be despaired of nor too well to be sure of." All these factors make acute appendical disease treacherous and cause a high mortality in this age group.

In children above the age of 5 years appendicitis becomes increasingly common but is somewhat easier to diagnose because the surgeon can obtain some history, however fragmentary, from the patient.

Appendicitis in the child proceeds through the same established sequence of symptoms and physical findings as in the adult: generalized abdominal pain, nausea and vomiting, tenderness, fever and leukocytosis. Without careful and intelligent questioning of the patient or of the parents the history in its correct chronologic order, so important for correct diagnosis, cannot be obtained.

Initial abdominal pain, either paraumbilical or epigastric, was the first symptom in from 75 to 90 per cent of a series of reported cases. It was followed by nausea and vomiting in from 75 to 95 per cent, with subsequent development of local tenderness over the appendix in a like percentage (table 2). Rigidity, observed in from 75 to 80 per cent of the cases, should never be considered essential to diagnosis, since its presence indicates that the inflammatory process has passed through the visceral peritoneum and involved the parietal peritoneum, a late sign. Chills are associated with acute appendicitis in children in approximately 5 per cent of cases; they demand early treatment to prevent involvement of the portal vein or of the liver. Diarrhea is occasionally observed, especially if the appendix is in the pelvis. Routine rectal examination is valuable in making a diagnosis, for the shallow pelvis of the child permits much more thorough exploration than is possible in the adult.

The white blood cell count in cases of appendicitis in children may be of equivocal value. One occasionally sees a child with the typical history and physical findings of appendicitis and a normal white cell count, the diagnosis being confirmed at operation. A normal white cell count should never be thought to exclude appendicitis if the history and abdominal findings are suggestive. The average leukocyte count in our series of cases was 15,000 per cubic millimeter. Counts above 20,000 per cubic millimeter are not common in cases of uncomplicated appendicitis.

Rapidity of Advance Toward Perforation.—Pathologically the process is too often far advanced when the child is first seen. A gangrenous or a ruptured appendix with local peritonitis is the rule rather than the exception, and spreading peritonitis is a common finding (table 3). In general, 50 per cent of all patients with acute appendicitis under the age of 13 years require drainage at operation, as do approximately 95 per cent of the group below the age of 5 years. In our own series drainage was considered necessary in 32.1 per cent of cases.

TABLE 2.—*Acute Appendicitis in Infancy and Childhood (Birth to 12 Years): Analysis of Clinical Observations*

Author	Cases	Boys	Girls	Previous Attacks	Associated Infection of Respiratory Tract	Initial Pain	Nausea and Vomiting	Tenderness	Abdominal Rigidity	Average Temperature	Chills	Distention	Average White Blood Cells
Litchfield, H. R., and Denbo, L. H.: Acute Abdominal Conditions in Children, Illinois M. J. 63 : 222, 1933.....	116	62%	38%	..	....	90%	99%	83%	76%	101 F.	6.8%	19%	16,000
Seiger [15].....	61	67%	23%	....	....	90%	72%	80%+	73%	Variable	.....	....	17,000
Cohen [6].....	312	62%	38%	....	8.6%	75%	85%	75%+	75%	.....	.....	....	17,000
Freedman [23].....	42	....	....	16%	45%	....	....	.....	....	100.4 F.	.....	....	14,200
Hudson [10].....	200	....	....	....	....	99%	92.8%	94.4%	83.4%	.....	.....	....	.....
Hamilton, H. B.: Nebraska M. J. 23 : 165, 1938.....	76	....	....	36%	52%	75%	75%+	90%	75%	100.2 F.	.....	....	16,000
McLaughlin and Davis (this paper).....	56	60%	40%	....	....	75%	90%+	95%+	75%	100.4 F.	5%	....	15,000

TABLE 3.—*Appendicitis in Infancy and Childhood (Birth to 12 Years): Analysis of Pathologic Observations in Relation to Treatment and Mortality*

Author	Year	Cases	Percentage of Admissions for Abdominal Disease	Pathologic Process								Percentage Treated by Drainage	Deaths	
				Acute Catarrhal or Suppurative Condition		Gangrene		Rupture; Abscess		Rupture; Peritonitis			Number	Percentage
				Cases	%	Cases	%	Cases	%	Cases	%			
Litchfield, H. R., and Denbo, L. H.: Acute Abdominal Conditions in Children, Illinois M. J. 63 : 222, 1933.....	1921	116	60	31	25	11	9	15	12	59	47	59	29	25
Lanman [38].....	1921	223	32.3	122	55	..	..	65	29.5	36	16.1	45+	29	13
Beekman [6].....	1925	316	95 Infections	...	..	..	..	..	..	..	..	..	22	7
Seiger [15].....	1926	61	....	...	..	..	..	..	..	..	..	50	5	8.2
Cohen [6].....	1927	312	85 Infections	...	..	..	..	..	..	..	..	20	13	4
Freedman [23].....	1929	42	....	24	57	..	..	18	43	..	..	57	2	4.8
Horgan and Horgan [16].....	1929	236	74	122	51	11	4.6	28	11.6	75	31.7	43	20	8.4
Keyes [17].....	1934	380	....	...	..	..	..	..	..	..	..	..	30	7.89
Hudson [10].....	1934	200	65	...	..	..	..	..	31	..	16	60	..	..
Hamilton, H. B.: Nebraska M. J. 23 : 165, 1938.....	1937	76	....	47	61	..	..	29	39	..	..	38	2	2.6
McLaughlin and Davis (this paper).	1939	56	62.9	38	68.9	..	..	7	12.5	11	19.6	32.1	5	8.9

Several anatomic and physiologic reasons account for the rapid progression to perforation and peritonitis in children under the age of 6 years.

(*a*) The cecum lies higher and the appendix is less often retrocecal than in older children, making the chances for general peritonitis greater when perforation occurs.[11]

(*b*) The lumen of the appendix is proportionately large, offering material free entrance into the appendix, with the possibility of obstruction.

(*c*) Lymphoid tissue gradually increases in the appendix of the child as the latter grows older, with its susceptibility to infection.[4a]

(*d*) The virulence of Bacillus coli communis in the infant increases with age.[4a]

(*e*) The appendical wall in young children is thin, offering little defense to virulent infection.[12]

(*f*) The omentum is underdeveloped at this age, giving little protection.[13]

(*g*) The long mesocecum usually present at this age increases the mobility of the cecum.[14]

(*h*) The child's relatively longer appendix tends to wander and give typical physical findings.[14]

Treatment.—Treatment consists in making the earliest possible diagnosis and in surgical removal of the appendix, preferably through a muscle-splitting incision. Even when there is reasonable doubt as to the diagnosis it is safer to remove the appendix, for the tragedy of one fatal mistake far outweighs any misgivings one may have in occasionally removing a normal appendix.

Removal of the appendix may not always be feasible in the large group of children who are first seen with a well formed appendical abscess. If at operation an abscess is encountered with the appendix incorporated in its medial wall, simple drainage, we believe, is the indicated procedure, with subsequent removal of the appendix in from six to eight weeks. Only when the appendix, presenting itself readily in the center or on the lateral side of the abscess cavity, can be removed without danger of contaminating the general peritoneal cavity is appendectomy carried out at the first operation.

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11. Carson, H. W.: Abdominal Pain in Children, Canad. M. A. J. **20**:587, 1929.

12. Fraser, J.: Mesothelial Reactions in Childhood, Brit. M. J. **2**:47, 1931.

13. (*a*) Poynter, C. W. M.: Concerning the Great Omentum, M. Clin. North America **12**:499, 1928. (*b*) Hughes, B.: Abdominal Crises in Childhood, Practitioner **125**:65, 1930. Fraser.[4a]

14. Stone, J. S.: Differential Diagnosis of Acute Abdominal Conditions in Childhood, Boston M. & S. J. **189**:303, 1923. Ladd.[5]

Children who present on admission evidence of spreading peritonitis offer a real problem. In the absence of unmistakable signs of general peritonitis our practice is to proceed immediately with appendectomy and, if necessary, drainage. Two factors influence this course in dealing with children. In the first forty-eight hours of the attack, even when the degree and extent of tenderness and rigidity suggest spreading peritonitis, operation may disclose only a diffusely inflamed or a gangrenous appendix without perforation but with a large quantity of free sterile peritoneal fluid. Appendectomy without drainage results in prompt, uncomplicated recovery; yet clinically it is impossible to determine the exact degree of peritonitis.

The second important factor is that anatomically the child's peritoneal cavity is not well adapted to the delayed (Ochsner) method of treatment, for the reasons previously stated. Seiger [15] and Stephens [2] expressed agreement with this opinion. Only in certain selected cases, in which there are a high temperature, a fast pulse and diffuse rigidity after an illness of three or more days, is the delayed treatment the method of choice. In such cases the extent of the disease and the general condition of the patient constitute a poor surgical risk, and it is our opinion that surgical drainage is never life saving in cases of established general peritonitis.

Factors in Mortality.—The various reported series of children operated on for acute appendicitis and its accompanying complications have shown a mortality ranging from 3 to 15 per cent. The two most important factors in this connection in any series are the age of the patient and the extent of the pathologic process found at operation. In series composed chiefly of young children the mortality is very high, as has been noted. In the entire group from birth to the age of 12 years the mortality varies with the number of patients with perforation of the appendix and with the extent of the peritonitis. Thus, Horgan and Horgan,[16] with a series of 236 children operated on for acute appendicitis, reported no mortality in 122 whose appendixes were not perforated; 9 per cent mortality in 11 whose appendixes were gangrenous; 18.6 per cent mortality in 75 whose appendixes were gangrenous and perforated, and a mortality of 17.8 per cent in 28 whose appendixes had ruptured with abscess formation. In our series of 56 children the mortality was 8.9 per cent. There were no deaths among those with acute appendicitis but no rupture; 1 death (a mortality of

15. Seiger, S. J.: Appendicitis in Infancy and Childhood, Surg., Gynec. & Obst. **42**:536, 1926.

16. Horgan, E., and Horgan, J.: Acute Surgical Conditions Within the Abdomen Occurring During Infancy and Childhood: Study of Three Hundred and Nineteen Cases, Arch. Surg. **18**:2271 (June) 1929.

14.3 per cent) among those with perforation and localized abscess, and 4 deaths (36.3 per cent) among 11 who had spreading or general peritonitis.

The factors which we believe to be chiefly responsible for the high incidence of perforation and its attendant mortality are: (1) the difficulty of diagnosis in the early stages of the disease, (2) the rapidity with which the changes progress to perforation and (3) the administration of purgatives by the mother or the physician.

The first two factors are well appreciated and require no further comment. The crusade against purgation has, however, just begun. Keyes [17] recently reported a mortality of 17.6 per cent in 193 children with acute appendicitis who had received a laxative prior to admission and a mortality of 2.4 per cent in 42 children with the same disease who had received no purgatives. Until both mothers and physicians have been taught that laxatives have no place in the treatment of acute abdominal disease, management of this problem will continue to show little improvement.

Differential Diagnosis.—Smith,[18] in a critical analysis of the observations on 146 children admitted to the hospital with a major complaint of abdominal pain, found that 68 per cent, or approximately two thirds, had acute surgical abdominal disease. In the remaining third the pain was due to a variety of nonsurgical conditions, and it is these which must be excluded by differential diagnosis. Since appendicitis is much the most common acute lesion requiring surgical treatment in this group, the problem often resolves itself into differentiating appendicitis from the more common conditions which do not require operation. In our experience the following diseases have offered the principal difficulties in diagnosis: (1) enterospasm, (2) acute sore throat or infection of the respiratory tract with abdominal pain, (3) mesenteric adenitis, (4) cyclic vomiting with acidosis, (5) pyelitis and cystitis, (6) pneumonia with abdominal pain and (7) abdominal purpura.

1. Enterospasm. This is considered by Heiman and Cohen [19] the most frequent cause of abdominal pain between the ages of 4 and 12 years. In the infant it is commonly induced by hunger, tends to recur at the same time each day and is usually controlled by food and atropine. In the older child the picture may be confusing. The three characteristic symptoms are paraumbilical pain, vomiting and constipation. The pain results from spasm of the smooth muscles, comes on

17. Keyes, E. L.: Deaths from Appendicitis, Ann. Surg. **99**:47, 1934.

18. Smith, F. H.: Diagnosis of the Acute Abdomen in Children, Virginia M. Monthly **54**:271, 1927.

19. Heiman, H., and Cohen, P.: Abdominal Pain in Children Due to Enterospasm, Arch. Pediat. **45**:383, 1928.

suddenly, is severe and tends to recur at intervals of several weeks. Examination discloses no local tenderness, muscle guard or rigidity and usually no fever or leukocytosis, but a spastic, cordlike bowel can frequently be palpated. Administration of atropine usually results in prompt recovery.

2. Infection of the respiratory tract. The frequent association of an acute sore throat or infection of the upper respiratory tract with abdominal pain is now well appreciated. The abdominal pain is characteristically paraumbilical and tends to be rather severe but is not accompanied by local tenderness or rigidity. Brennemann [20] concluded that this abdominal pain is resultant from swollen abdominal mesenteric glands but warned that associated appendicitis may be present. Subsequently [21] he has emphasized the great frequency with which acute appendicitis is seen in association with infections of the upper respiratory tract. In 1918 Evans [22] published his observations on the association of acute tonsillar infections with appendicitis among students at the University of Wisconsin. He found, over a five year period, active or recent acute tonsillar infection in 86 per cent of 236 patients admitted to the hospital with acute appendicitis. Freedman [23] reported the occurrence of acute appendicitis in 42 children during an epidemic of acute infections of the upper respiratory tract. Undoubtedly infections involving the upper respiratory tract have a special predisposition to invade the appendix, and when this occurs the process advances rapidly to perforation. The important clinical fact is that the two conditions frequently coexist, and the presence of localizing tenderness over the appendix with muscle guard or rigidity, if accompanied by a sore throat, demands extremely prompt attention.

3. Mesenteric adenitis. This condition offers one of the most difficult problems in differential diagnosis. Enlargement of the glands in the mesentery of the terminal portion of the ileum has been thought to be a local manifestation of a general process with the primary infection in the nasopharynx (Adams and Olney [24]). This is suggested by the frequency with which a recent or an active infection of the throat

20. Brennemann, J.: Abdominal Pain of Throat Infections, Am. J. Dis. Child. **22**:493 (Nov.) 1921.

21. Brennemann, J.: "Abdominal Pain of Throat Infections in Children" and Appendicitis, J. A. M. A. **89**:2183 (Dec. 24) 1927.

22. Evans, J. S.: Epidemiology of Acute Appendicitis in Relation to Acute Nasal and Tonsillar Infections, Wisconsin M. J. **17**:91, 1918.

23. Freedman, H. J.: Forty-Two Cases of Appendicitis in Children Occurring During an Epidemic of Upper Respiratory Tract Infections, Arch. Pediat. **46**: 604, 1929.

24. Adams, W. E., and Olney, M. B.: Mesenteric Lymphadenitis and the Acute Abdomen, Ann. Surg. **107**:359, 1938.

is found in association with mesenteric adenitis. Stephens [2] concluded that the process is due to infection in the lower portion of the ileum and not to either a pharyngeal or an appendical lesion. Clinically the picture is characterized by recurrent bouts of generalized abdominal pain with little tendency to localize. Nausea and vomiting are the rule, and diarrhea is occasionally a feature. Examination discloses diffuse soreness, but localized tenderness is not constant. The enlarged glands can be palpated only occasionally. The temperature is usually somewhat higher than in cases of uncomplicated appendicitis and the white blood cell count ranges from 10,000 to 20,000 per cubic millimeter. Free fluid is not present as a rule but was present in 2 of 5 cases in which we performed exploration. Differentiation of this condition from appendicitis is often impossible, and if there is reasonable doubt it is much wiser to open the abdomen. The appendix may show little or no pathologic change, but firm, enlarged nodes varying in diameter up to 1.5 cm. are found distributed through the mesentery of the terminal portion of the ileum. These glands on section show only diffuse hyperplasia, and tuberculous involvement is rare. Southam [25] observed that appendectomy usually results in permanent cure of the condition; this has been our observation in 4 instances. After operation the temperature often mounts to 103 or 104 F., but it promptly subsides, and the patient makes an uneventful recovery.

4. Cyclic vomiting with acidosis. This condition is not infrequently mistaken for appendicitis. Severe and persistent vomiting is usually the initial symptom. Abdominal pain develops later, but there is no localizing tenderness or rigidity. The characteristic facies of acidosis is usually present, the cherry-red cheeks and lips and the overanxious countenance. The odor of acetone is readily detected on the breath, and the urine is laden with acetone and diacetic acid. The white blood cell count is usually not elevated. Gibson and Mann [26] have suggested that as an aid in diagnosis the patient be given a sufficient amount of water by mouth to produce vomiting. Immediately after emesis the patient tends to relax, the limbs are extended and the abdominal tenderness disappears. The accepted therapeutic measure of giving dextrose by vein is also diagnostic and usually solves the problem, since the child often stops vomiting during administration of the venoclysis and falls asleep. The symptoms then rapidly clear up, and recovery is prompt.

5. Pyelitis and cystitis. Pyelitis and, to a lesser extent, cystitis sometimes closely simulate appendicitis. The higher temperature, the

25. Southam, A. H.: The Abdominal Emergencies of Childhood, Practitioner **120**:364, 1928.

26. Gibson, J., and Mann, J.: Mimicry of the Acute Abdomen in Cases of Cyclic Vomiting in Children, Canad. M. A. J. **17**:45, 1928.

atypical onset and the presence of chills, tenderness in the renal regions and in the flanks and pyuria usually make the diagnosis clear, although appendicitis with the appendix lying in an extracecal or a high retrocecal position may simulate pyelitis even to the presence of pyuria. The temporary ureteral block associated with pyelitis may prevent the appearance of pus in the urine. If there is a reasonable doubt as to the correct diagnosis, it is certainly safer to remove the appendix, although the absence of appendical pathologic change and the subsequent development of pyuria may prove the preoperative diagnosis incorrect.

6. Pneumonia. Pneumonia is one of the most difficult conditions to differentiate from acute appendicitis in children. Adams and Berger [27] reported that 17.6 per cent of a series of 145 patients at the Boston City Hospital who were proved to have pneumonia had been admitted to the surgical wards with an initial diagnosis of acute appendicitis. They noted that cough and pain in the chest or vomiting and abdominal pain are not determining symptoms. The child with pneumonia usually looks more ill and shows more systemic reaction; the abdominal rigidity is of a different type; the temperature, the pulse rate and the respiratory rate are usually much higher, and the white blood cell count ranges from 20,000 to 42,000 per cubic millimeter. Careful examination of the chest is always necessary to find the lesion in its early stages, and in case of doubt a flat roentgenogram of the chest may be of great assistance.

7. Abdominal purpura. The clinical syndrome of Henoch's purpura and abdominal allergy simulating acute abdominal disease has been emphasized by Frazer,[28] Bailey [29] and Althausen, Deamer and Kerr.[30] In children this condition, characterized by petechial or massive hemorrhage beneath the peritoneum of the bowel or its mesentery, may simulate acute disease of the appendix or intussusception.

Althausen and his associates [30] suggested the following points in differential diagnosis, favoring purpura: (*a*) a family history of allergy or urticaria, (*b*) a personal history of allergic disorders or sensitivity, (*c*) eosinophilia and (*d*) demonstrable cutaneous sensitivity.

Unfortunately, cutaneous manifestations often appear late, and without a suggestive history careful search may not be made for petechiae.

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27. Adams, F. D., and Berger, B. J.: Differential Diagnosis of Lobar Pneumonia and Appendicitis in Children, J. A. M. A. **79**:1809 (Nov. 25) 1922.

28. Frazer, I.: Purpura Simulating the Acute Abdomen, Lancet **2**:525, 1930.

29. Bailey, H.: Purpura as an Acute Abdominal Emergency, Brit. J. Surg. **18**:234, 1930.

30. Althausen, T. L.; Deamer, W. C., and Kerr, W. J.: The False Acute Abdomen, Henochs Purpura and Abdominal Allergy, Ann. Surg. **106**:242. 1937.

The application of a tourniquet to an arm for three minutes may be useful in demonstrating multiple petechial hemorrhages below the site of application.

Even if one realizes that this disorder or a similar abnormality is present, the clinical picture may indicate surgical intervention. We recently observed a 6 year old boy known to have hemophilia who was admitted to the hospital with a history and physical findings typical of appendicitis. Operation, carried out because of definite physical findings, disclosed a large retroperitoneal hemorrhage with bleeding into the mesocecum. Recovery was slow but without serious complications, although several transfusions were necessary to control the tendency to bleed.

In the differential diagnosis of appendicitis, abdominal pain due to inflammation of Meckel's diverticulum must be considered, but this requires prompt operation and is not to be grouped with the previously discussed seven causes of abdominal pain in infancy and childhood which do not require surgical intervention. This diverticulum has a low incidence, is congenital and becomes of clinical interest only when it contributes to the development of intussusception or to acute intestinal obstruction, becomes acutely inflamed or causes peptic ulcer with intestinal hemorrhage.

Although Meckel's diverticulum persists in approximately 2 per cent of all persons, complications attributable to it are relatively few. Its association with intussusception has been observed in from 4 to 8 per cent of the reported series.[31] Collins [32] collected 11 cases of Meckel's diverticulum from among 500,000 new admissions to the Los Angeles General Hospital. We have observed 1 case in our series of 89 admissions for acute abdominal disease requiring operation in children under the age of 12. The patient, a boy 6 years of age, presented findings typical of acute appendicitis, although the point of maximum tenderness was slightly more medial than is usual. Just before operation was undertaken he passed some rather bright blood by rectum, which suggested the possibility of Meckel's diverticulum. The appendix was normal, but an inflamed diverticulum was removed from the terminal portion of the ileum. Examination of the specimen showed it to contain in its lining mucosa typical gastric tissue with a definite peptic ulcer.

Cases of Meckel's diverticulum in which there is no bleeding but in which signs of an acute abdominal disorder develop are almost

31. Wade, R. B.: Some Abdominal Conditions in Children, M. J. Australia **2**:28, 1924. Stephens.[2] Ladd.[5]

32. Collins, D. C.: Acute Abdomen Caused by Meckel's Diverticulum, Canad. M. A. J. **37**:564, 1937.

invariably mistaken for instances of appendicitis. In none of Collins' [32] 11 cases was the correct diagnosis made before operation or postmortem examination.

The frequent presence of gastric or pancreatic mucosa within the diverticulum, with ulceration and intestinal hemorrhage, should make one suspect the presence of this condition in any child who passes bloody stools in the absence of signs and symptoms suggesting intussusception or Henoch's purpura.

INTUSSUSCEPTION

Intussusception is the second most frequently encountered cause of an acute surgical condition of the abdomen in infancy and childhood. Although described by Hippocrates, it is still too often considered a rare pathologic entity.

Incidence.—According to the reported series (table 1) intussusception is the most common acute lesion requiring surgical treatment in children under the age of 2 years, and comprises from 4 to 8 per cent of all acute abdominal conditions from birth to the age of 12 years. In our own series of cases intussusception was responsible for 4.4 per cent of admissions for acute abdominal disease. Intussusception accounts for 60 to 75 per cent of the admissions for acute intestinal obstruction in infants and children.[33] Since this lesion develops most frequently in children between the ages of 6 and 18 months, a period when other acute inflammatory lesions are relatively infrequent, its importance is further emphasized.

Approximately 65 per cent of intussusceptions occur in boys. The patients are usually well developed and well nourished babies, previously in good health, who have had better than average care.

It is interesting to note that in certain sections of the world, chiefly Australia, very large numbers of cases are reported. Barrington-Ward [34] reported intussusception in 37.6 per cent of admissions to the Great Ormond Street Hospital in London, England, during the past five years. This frequency must not be considered a true index, however, for through established custom patients with certain types of conditions are usually sent to specific hospitals.

Causes.—Many etiologic factors have been observed and suggested for intussusception (table 4). The presence along the intestinal tract of some pathologic exciting lesion such as Meckel's diverticulum, a

33. Lanman, T. H.: The Surgical Abdomen in Children, Boston M. & S. J. **185**:489, 1921. Cohen.[6]

34. Barrington-Ward, L. E.: Diagnosis and Treatment of Acute Abdominal Conditions in Children, Tr. Med.-Chir. Soc. Edinburgh, 1935-1936, p. 25; in Edinburgh M. J., March 1936.

TABLE 4.—*Intussusception in Infancy*

Specific Cause	Treatment	Effect of
Meckel's	Other	Open	Pal-	Per-centage

TABLE 4.—*Intussusception in Infancy*

Author	City	Year	Cases	Boys	Girls	Specific Cause: Meckel's Diverticulum	Specific Cause: Other Conditions	Bloody Stools	Palpable Masses	Treatment: Enema	Treatment: Open Reduction	Treatment: Resection	Treatment: Colostomy	Treatment: Not Stated	Deaths	Percentage Mortality	Effect of Delay on Mortality
Hess, J. H.: Intussusception in Infancy and Childhood, Arch. Pediat. **22**: 655, 1905	Chicago	1905	1,020 collected	..	..	..	..	..	..	151 (65 reduced)	549 (339 recovered)	109 (35 recovered)	35 (9 recovered)	176 (60 recovered)	513	50.2	.....
Clubbe [36]	Sydney, Australia	1907	114 14 yr.	..	..	..	..	94%	..	138 (14 reduced)	124 (After enema)	8 (0 recovered)	..	..	40	33.2	Fatalities av. 58 hr.
Romanis [35]	London	1918	374	..	..	3	7	..	..	...	331	30	10	3	121	32.3	.....
Litchfield, H. R., and Denbo, L. H.: Acute Abdominal Conditions in Children, Illinois M. J. **63**: 222, 1933	Washington, D. C.	1921	11	8	3	..	..	..	..	...	...	..	..	..	...	....	.....
Lanman [38]	Boston	1921	72	..	..	..	..	..	..	...	72	..	..	..	30	41	87% fatalities over 24 hr.
Fraser [4b]	Edinburgh	1922	300 (9 yr.)	..	..	..	..	..	..	...	...	..	..	..	...	....	.....
Harper, W. F.: Acute Intussusception, Boston M. & S. J. **18**: 700, 1922	Boston	1922	112	63%	37%	..	..	..	..	...	112	..	..	..	44	39.2	.....
Wade [31]	Sydney Australia	1924	519 13 yr.	297	147	..	..	Seen (av. 7 hr.)	..	...	Yes	..	..	..	73	14.06	.....
Cohen [6]	New York	1927	22 (4.5 yr.)	15	7	..	..	86%	77%	2	19	..	..	..	5	22.7	All fatalities over 24 hr.
Carson [11]	London	1929	17	..	..	..	..	..	..	...	17	..	..	..	0	0	(Last 17 cases)
Horgan and Horgan [16]	Washington, D. C.	1929	13 4 yr.	..	..	..	..	..	..	...	9	2	1	1	4	30.7	.....
Ladd [5]	Boston	1930	273	..	..	7 (last 130 cases)	..	Seen (av. 12 hr.)	..	...	Yes	..	..	..	66 4	24 8	..... (Last 50 cases)
Bailey [29]	Birmingham, England	1930	9 collected	..	..	..	9 essential purpura	100%	100%	...	5	4 1 death	..	..	2	22	.....
Miller, E. M.: Abdominal Emergencies in Infancy and Childhood, Illinois M. J. **63**: 569, 1933	Chicago	1933	20	..	..	2	..	100%	..	...	18	2	..	..	9	45	78% fatalities over 24 hr.
Portis, B.: Acute Surgical Abdominal Conditions in Children, Illinois M. J. **63**: 222, 1933	Chicago	1933	6	..	..	2	..	..	..	2	4	..	..	..	0	0	.....
Hudson [10]	Boston	1934	372	61%	39%	14	11	..	..	...	..	Yes	..	..	0	0	(Last 60 cases)
Barrington-Ward [34]	London	1936	88	65%	..	..	..	84%	..	...	Yes	..	..	..	..	20.4	.....
McLaughlin and Davis (this paper)	Omaha	1939	4	50%	..	0	4	100%	100%	...	4	0	0	0	1	25	.....

polyp or a new growth has been suggested as the cause by Romanis,[35] Ladd [5] and Hudson.[10] They reported the presence of such factors in from 4 to 8 per cent of their series. Alteration in diet with hyperperistalsis and diarrhea resulting in irritation of the lower part of the ileum has been suggested as an etiologic factor, since the patients are usually of the age at which a rather general diet is instituted. Wade [31] concluded that inflamed lymph tissue in the lower part of the ileum, acting as a polyp, is usually present. Fraser [4b] stated that some defect in the structural arrangement of the splanchnic nervous system is a likely cause, and Treves as well as Clubbe [36] suggested that irregular action of the intestinal musculature with spasm of the circular coat may produce invagination. Clubbe [36] has suggested the abnormal motility of the colon, due to its persistent mesentery, as a predisposing cause. Finally, Power, cited by Clubbe,[36] has called attention to the disproportionate growth of the colon and the ileum during infancy, both being approximately the same size at birth. In 2 of our cases a congenital peritoneal band crossing the cecum was felt to be the cause of intussusception.

Types.—Intussusception has been described as the "catching up of one piece of bowel within another piece." For practical purposes three types should be considered:

1. An enteric type, distinctly unusual and involving only the small bowel.

2. A colic type, involving only the colon. It is not frequent in children; it is occasionally encountered in the sigmoid colon in older patients.

3. An enterocolic type, involving the terminal part of the ileum, the cecum and the colon.

The last form is much the most common one in infancy and childhood, beginning in the terminal 6 inches (13 cm.) of the ileum and from there proceeding to the cecum and the distal portion of the colon. As it advances, the mesentery of the terminal portion of the ileum is carried with it, the process resulting in constriction of the invaginated part, edema, mucosal bleeding and finally necrosis.

In the effort to expel the abnormal bolus within the bowel the intussusceptum is pushed farther and farther along the colon until it may become palpable by rectum or may protrude through the anus. The excess of mucus within the lumen of the bowel becomes mixed with blood from the engorged mucosa and when passed by rectum is one of the diagnostic features of the condition. This phenomenon appears

35. Romanis, W. H. C.: The Abdominal Emergencies of Childhood, Practitioner **120**:364, 1928.

36. Clubbe, C. P. B.: The Diagnosis and Treatment of Intussusception, Edinburgh, Y. J. Pentland, 1907.

in practically all cases in from six to twelve hours and was observed in each of our 4 cases within seven hours after the onset of symptoms.

Prior to the days of operative intervention in such cases an occasional recovery was reported after the sloughing away of the entire intussusceptum with reestablishment of intestinal continuity by plastic adhesions at the site of invagination. This occurrence was distinctly uncommon, however, and occurred in less than 3 per cent of cases. When the condition is untreated death usually results in a few days from acute intestinal obstruction with associated toxemia.

Symptoms.—One rarely sees a patient with acute intussusception during the first moments of illness, but the story which may be obtained from the mother or nurse is so typical that there can be little doubt as to the condition. A previously well baby suddenly screams and draws up its legs as if in agony. In a few moments the screaming ceases, and the infant appears to be in shock. The face is pale and beaded with perspiration, the lips are pinched and slightly blue and the whole countenance indicates that something serious has happened. After a variable period, ranging from a few moments to several hours, the child's color returns and the symptoms of shock disappear. Recurrent attacks of the initial severe pain are not the rule, but at intervals the child whimpers or cries briefly as the intussusceptum is forced along the colon by intestinal peristalsis. Vomiting usually does not occur until late in the disease. In a period varying from six to twelve hours bloody mucus or currant jelly-like material is passed by bowel.

Abdominal distention, tenderness and muscle spasm are late features. During the first twenty-four hours the abdomen is usually flat or scaphoid. Palpation frequently discloses a peculiar emptiness of the entire right side of the abdominal cavity (Dance's sign), resulting from migration of the cecum and ascending colon with the advancing intussusceptum. The mass is usually palpable in the right upper quadrant of the abdomen, along the line of the ascending colon or above the umbilicus, but it may appear anywhere along the course of the colon. The tumor tends to be sausage shaped and several inches in length, but it may be felt as a small spherical mass which becomes more prominent during straining. Inability to palpate the tumor does not exclude an intussusception, since the large liver of a small child may completely cover the mass for a time in its progression through the colon. Rectal examination often first discloses the presence of bloody mucus and should never be omitted. A rectal mass can rarely be palpated under twenty-four hours; this finding, therefore, is of prognostic importance rather than of aid in diagnosis. As in any case of acute intestinal obstruction, the temperature and the white blood cell count are of little value in making a diagnosis in the early stages.

Differential Diagnosis.—Four conditions confused with intussusception in differential diagnosis will be briefly considered:

1. Acute appendicitis. As has been noted, this condition is uncommon under the age of 2 years, and its onset is neither as sudden nor as dramatic as that of intussusception. Vomiting is usually an early symptom, with associated tenderness, rigidity and distention.

2. Acute enterocolitis. This condition rarely begins as suddenly as does intussusception. The bowel movements are usually excessive. Abdominal pain and passage of excessive amounts of mucus and later of blood are common to the two conditions, but in the presence of enterocolitis fecal matter continues to be passed, which is never true of intussusception. Neither an abdominal mass nor intestinal obstruction develops in the former condition. Occasionally acute enterocolitis with its associated hyperperistalsis results in intussusception.

3. Rectal prolapse. The inability to introduce the finger into the rectum beside the protruding mass, in a simple rectal examination, excludes intussusception.

4. Abdominal (Henoch's) purpura. This condition may simulate intussusception in almost every detail, even to the presence of an abdominal mass due to subperitoneal hemorrhage and the passage of blood by rectum. Differentiation is aided by (*a*) a purpuric rash on the body, usually on the extensor surfaces of the extremities, (*b*) petechiae produced by a tourniquet test, (*c*) the platelet count and (*d*) the age of the patient (abdominal purpura rarely appears in children under the age of 5 years, while most patients with intussusception are under the age of 2 years).

The subperitoneal hemorrhages commonly seen in cases of abdominal purpura may predispose to the development of intussusception, 9 instances having been collected from the literature by Bailey.[29] If reasonable doubt exists it is certainly wise to consider the condition intussusception and explore the abdomen at once.

Treatment.—It is now generally agreed that the safest and most satisfactory method of handling intussusception is surgical intervention as soon as possible after the diagnosis has been made, provided the general condition warrants operative intervention. Some still recommend, in cases of early involvement, rectal injections as a preliminary to surgical reduction. The danger of this procedure lies in subsequent belief that the intussusception has been relieved when in reality the small initial portion of the intussusceptum has remained unreduced. The six hours lost before this mistake is appreciated may mean the difference between a simple operative reduction and resection with its high attendant mortality.

The surgeon must constantly remember that intussusception is essentially acute intestinal obstruction. We believe that restoration of the fluid balance before operation is most important and prefer to administer lactate-Ringer (Hartman's) solution subcutaneously. This can be done while the operating room is being prepared for use. Gastric lavage is also an important preoperative measure, since removal of the usual retained fluid curbs vomiting with the hazard of pulmonary aspiration.

Ether given by the open drop method is the anesthetic of choice, but both the amount used and the total time taken should be reduced as much as possible. The surgeon and his assistant should be scrubbed and ready to operate before administration of the anesthetic is begun, so that no time may be lost. The incision is placed to the right of the umbilicus, and sufficient exposure is obtained to permit introduction of the two index fingers. The tumor is located, and reduction is carried out within the abdomen by milking the intussusceptum backward through the intussuscipiens until the tight edematous ring marking the origin of the intussusception is reached. It is best at this point to deliver the bowel into the wound; this is usually accomplished without great difficulty. The reduction is then completed under direct vision, and in the absence of any specific etiologic factors the abdomen is closed. Tacking the cecum to the lateral peritoneal wall is not considered necessary or wise, since the incidence of recurrence is low and this procedure is opposed to physiologic principles. If Meckel's diverticulum is an etiologic factor it should be removed, but routine appendectomy is not to be advised. Double intussusception has occasionally been observed, and its possibility should not be overlooked.[6]

In cases in which operation is performed early surgical reduction is usually easy. If many hours or several days have elapsed reduction may be extremely difficult or impossible. In such a case one may wrap a warm, moist sponge about the intussusception and apply gentle pressure with the grasping hand. After some of the edema has been driven out of the tumor mass, reduction may be possible. One is never justified in exerting traction on the distal portion of the colon, because of the great danger of tearing the bowel. If all efforts fail to accomplish reduction, one is left with the choice of either a resection or a colostomy.

Factors in Mortality.—The mortality in any large series of cases ranges from 15 to 45 per cent and is almost directly proportional to the delay in surgical treatment. The large number of patients who die come to operation late, when the condition requires either extensive manipulation of the intestine or resection. Wade,[31] with an extensive personal experience in the management of this condition, reported a mortality of 14.06 per cent in a series of 519 cases. That the mortality can be greatly reduced by prompter diagnosis and earlier operative inter-

vention is indicated by Hudson's [10] recently reported series of 60 consecutive cases with no mortality. The 1 death in our series of 4 cases occurred twenty-four hours after operation and was due to bilateral diffuse bronchopneumonia.

PNEUMOCOCCIC AND STREPTOCOCCIC PERITONITIS

Incidence and Portal of Entry.—Pneumococcic or streptococcic peritonitis is the third cause of acute abdominal disease requiring operation in infancy and childhood Table 5 shows these two types of peritonitis to be responsible for from 2 to 4 per cent of admissions for acute abdominal disease requiring operation. In our own series the incidence was 3.3 per cent.

In 1922, McCartney and Fraser [37] reported 56 cases of pneumococcic peritonitis in children under the age of 12 and from their clinical and operative findings concluded that the infection was genital in origin. Subsequent reports [38] have suggested that organisms may enter through the respiratory tract, the intestine or the blood stream as well as through the genital tract. Cole, [39] from his experience at the St. Louis Children's Hospital, also concluded that the infection may enter by more than one route. The frequent association of an active or subsiding infection of the upper respiratory tract has been suggested by Swartz [40] and Newell [38b] as indicating a likely point of entrance in most patients.

Both sexes are susceptible to pneumococcic or streptococcic peritonitis, although pneumococcic infection is found in a larger percentage of girls than of boys. Streptococcic peritonitis is much more common in the age group from birth to 3 years. Pneumococcic infection is seen more commonly in older children.

Symptoms and Course.—The clinical picture in each instance is characterized by abdominal pain, fever, persistent vomiting and frequently diarrhea (table 6). Localization of the pain is not the rule, but the frequent presence of tenderness over the right lower quadrant of the abdomen suggests strongly the possibility of appendicitis. Rigidity is not common and is a variable finding. The temperature ranges from 102 to 104 F., and leukocyte counts from 20,000 to 40,000 per cubic millimeter are commonly noted.

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37. McCartney, J. E., and Fraser, J.: Pneumococcal Peritonitis, Brit. J. Surg. **9**:479, 1922.

38. (*a*) Gordon, H.: Acute Suppurative Peritonitis, in Blumer, G., and Lane, C. G.: The Practitioners Library of Medicine and Surgery, New York, D. Appleton-Century Company, Inc., 1935, vol. 7, p. 407. (*b*) Newell, E. T., Jr.: Primary Streptococcus and Pneumococcus Peritonitis in Children, Surg., Gynec. & Obst. **68**:760, 1939. Fraser.[12]

39. Cole, W. H.: Pneumococcic Peritonitis, Surgery **6**:386, 1937.

40. Swartz, J.: Primary Streptococcic Peritonitis in Children, Surg., Gynec. & Obst. **45**:590, 1927.

TABLE 5.—*Peritonitis in Childhood Due to Pneumococcus and Streptococcus: Analysis of Clinical Data*

Author	Year	Cases	Organism		Boys	Girls	Average Age	Primary Infection				Treatment		Mortality, Percentage
			Streptococcus	Pneumococcus				Genital Tract	Throat	Chest	Blood Stream	Conservative	Immediate Drainage	
Lanman [33]	1921	16	10	6	..	..	...	..	..	..	.....	.....	.....	75
McCartney and Fraser [37]	1922	56	0	56	12	44	6	36	..	18	Terminal	.....	56	65
Beekman [8]	1925	18	4	14	3	15	...	..	..	2	Terminal	.....	18	65+
Lipshutz, B., and Lowenburg, H.: Pneumococcic and Streptococcic Peritonitis, J. A. M. A. **86**: 99 (Jan. 9) 1926	1926	22	9	13	5	17	1-6	3	22	..	9	4	18	100
Cohen [6]	1927	9	6	3	6	3	2-6	..	9	..	.....	.....	9	80
Swartz [40]	1927	14	14	0	5	9	85% 1-5	2	10	..	2	.....	14	79
Ladd [5]	1930	51	36	15	..	..	...	..	..	..	.....	Favored	Delayed operation	65
Hudson [10]	1934	29	..	..	..	..	...	..	Usual	..	Terminal	Favored	Delayed operation	..
Gordon [38a]	1935	40	31	9	17	23	1-6	2	28	..	All terminal	.....	40	81
Newell [38b]	1939	61	25	36	39	22	1-6	0	25%	..	Common	Favored	Delayed operation	78.5

TABLE 6.—*Pneumococcic Peritonitis in Infancy and Childhood: Analysis of Clinical Data*

Author	Cases	Average Age	Boys	Girls	Severe Emesis	Diarrhea	Fever	Average White Blood Cells	Peritonitis		Origin of Infection				Positive Peritoneal Puncture	Positive Blood Culture	Treatment		Mortality, Percentage
									Primary	Secondary	Throat	Chest	Genital Tract	Kidney			Conservative	Immediate Operation	
McCartney and Fraser [37]	56	6	14	44	++++	+++	104 F.+	33,000	38	18	..	18	36	..	..	Terminal	..	56	65
Beekman [6].....	14	Under 6	1	13	++++	+++	104 F.+	20,000 to 40,000	13	2	..	2	..	..	..	Terminal	..	14	65
Lipshutz, B., and Lowenburg, H.: Pneumococcic and Streptococcic Peritonitis in Infancy and Childhood, J. A. M. A. 86 : 99 (Jan. 9) 1926	13	1-6	1	12	++++	+++	104 F.+	32,000	..	..	..	..	5	..	13	5	..	13	100
Cohen [6].....	3	2-4	0	3	.....	.....	.....	.....	..	..	..	..	..	..	..	..	..	3	100
Ladd [5].....	15	..	..	..	.....	.....	.....	.....	..	..	..	..	..	..	..	..	Favored	Delayed	66
Gordon [38a].....	9	..	..	..	++++	+++	104 F.+	High	..	..	5	..	..	4	..	..	..	9	77
Newell [38b].....	36	1-10	22	14	++++	++++	102 F.+	20,000 to 40,000	12	24	8	..	0	16	..	17	..	Favored	61.1
McLaughlin and Davis (this paper)	2	4	..	2	++++	+++	102 F.+	30,000	2	..	..	..	2	0	0	0	Yes	Delayed	0

The acute fulminating condition progresses rapidly to generalized peritonitis with marked prostration and early death; particularly with the streptococcic infections, mortality figures vary from 90 to 100 per cent. In a certain percentage of cases pneumococcic infection tends to localize, with the development of an abscess after a few days. Such a collection of pus may be found anywhere within the abdomen but is usually located in the pelvis. In both of our cases the involvement was of this type, and complete recovery followed drainage of the abscess

Treatment.—The treatment of patients with primary peritonitis has been a matter of controversy for many years. Surgeons have been divided into two groups, one favoring early operation with drainage of the pelvis and the other recommending conservative measures until a localized abscess develops.

No definite course can as yet be accepted as best. Frequently the decision to carry out early operation is made because the presence of acute disease of the appendix cannot be adequately ruled out. In this problem peritoneal puncture is of the greatest value. If a few drops of pus can be obtained and the offending organisms identified, one feels more justified in pursuing an expectant course.

The use of specific serums for primary peritonitis has been the most encouraging recent advance in the treatment of the pneumococcic condition. Newell [88b] has recently reported the use of antipneumococcic rabbit serum with prompt recovery in 1 case and has stated the belief that this form of therapy may be of great value. As yet no data are available on the use of sulfapyridine (2-[paraaminobenzenesulfonamido]-pyridine) for this type of pneumococcic infection. Probably, through advances in specific treatment, reduction in mortality will be achieved, since a consistently high mortality follows all forms of surgical treatment with simple supportive measures in cases of acute diffuse involvement.

There are not as yet sufficient available data to enable one to evaluate the therapeutic effect of sulfanilamide in the treatment of streptococcic peritonitis. However, there is good reason to believe that the drug may be a valuable agent in the treatment of this condition, which now has an appallingly high mortality.

SUMMARY AND CONCLUSIONS

No attempt has been made to consider all the various lesions which may produce acute conditions of the abdomen requiring operation in infancy and in childhood. The purpose has rather been to stress the four most common causes and to present our own experience in the management of these. An effort has been made to review the important recent literature on the subject and to correlate the experience and conclusions of the various authors.

SUPERNUMERARY BREAST

TIBOR DE CHOLNOKY, M.D.
NEW YORK

The development of the supernumerary breast (polymastia or hypermastia) and its modality constitutes an interesting chapter in clinical observation. The subject is of clinical interest because of the differential diagnosis of supernumerary breasts and lipomas and other benign tumors and because of the discomfort caused by the swelling of aberrant breast tissue during pregnancy and childbirth. It is also important to establish that there is no evidence that carcinoma develops more frequently in these formations than in normal breasts.

There are in the literature almost six hundred references to congenital anomalies of the breast. In the human being the supernumerary organs develop either in the milk line or in locations that are atypical for human beings but normal for other mammals. A short sketch of the embryology and comparative anatomy may therefore be of interest, in addition to a description of some new cases and a summary of cases collected from the literature since the extensive study by Deaver and McFarland in 1918.

EMBRYOLOGY

According to the observations of Basch, Neumann, Schultz, Schmidt, Kallius and others, two lines of thickened epithelium running parallel to each other and longitudinally on the ventral surface appear first in the 4 mm. embryo. This anlage develops uniformly from the axilla to the pubic region and ends at the inside of the thigh (fig. 1). In the 10 mm. embryo the milk lines measure about 2 mm. in length and can be seen with the naked eye. With further development there is definite localization of epithelial cells in molehill formation at the level of the fourth rib, from which later the normal breast develops. The epithelial cells conglomerate at this level, gradually increase in volume and penetrate to the subcutaneous tissue. The first epithelial buds which will form the gland proper, as well as the epithelial prolongations which increase in size and form the primitive breast, appear in the 170 mm. embryo. In the 45 cm. fetus well developed ducts are present, opening to the future nipple, which is still under the level of the skin and remains there until after birth. In the normal person the milk line gradually

From the Skin and Cancer Unit of the New York Post-Graduate Medical School and Hospital, Columbia University, Attending Surgeon, Carl Eggers, M.D.

disappears with the exception of the anlages for the normal breasts. The occasional failure of this process of extinction accounts for the formation of breasts at other locations on the milk lines.

Some authorities, particularly Champneys, have stated the belief that supernumerary mammary glands are enlarged sweat glands and not true breasts. Champneys' theory was supported by Tandlau's observation of a patient in whom there was complete failure of development of the breast and nipple, together with total absence of sweat glands all over the body and partial absence of the sebaceous glands.

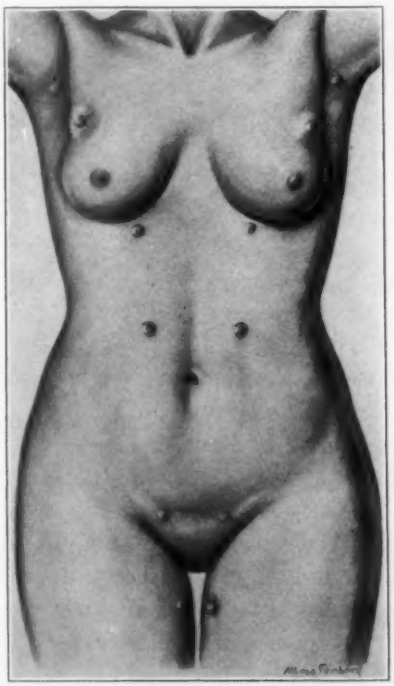

Fig. 1.—Schematic representation of the development of supernumerary breasts in the milk line.

COMPARATIVE ANATOMY

It was Geoffroy-Saint-Hilaire who, in 1836, suggested that man was descended from animals having multiple breasts. Darwin later subscribed to this theory. In his "Descent of Man" in 1871 he called attention to the fact that supernumerary breasts should be considered an atavistic manifestation.

Phylogenetically, inguinal breasts are found in the pouched mammals (monotremes and marsupials) as well as in the ungulates and cetaceans. In elephants, sirenia, bats of some types and most of the primates, breasts are confined to the pectoral region, as is also the case in some

rodents, e. g. the jumping hare (Pedetes cafer). Axillary breasts develop normally in the fruit bats and the flying lemur. Mammae are found in the inguinal region in one of the lemurs of Madagascar, in the acromial region in the gentle lemur (Hapalemur) and behind the axilla in the hutia (Capromys pilorides). The porcupine has a mammary gland on the anterior side of each axilla; in the nutria (Myocastor) the mammae are placed behind the scapula, while in the cetacea (whale, porpoise, dolphin) they are placed on the labia of the vulva. The viscaccia (Lagostomus maximus) and some other rodents have breasts on the dorsolateral aspect of each thigh. In the opossum there is commonly a breast in the midline of the abdomen and thorax, in addition to numerous other mammae.

According to Hartman, the largest number of breasts found in animals is in the South American marsupial (Monodelphis henseli), which has twenty-five, and in the insectivore tenrec of Madagascar (Centetes ecaudatus), which has twenty-two pairs. The latter is probably the most prolific of insectivores, as many as twenty young being brought forth at one birth. Among the primates, not only human beings but anthropoid apes (though perhaps less frequently) have supernumerary breasts. Aside from reports of a few unilateral nipples (reported by Hartman), Coolidge first recorded a case of symmetric supernumerary mammae in a chimpanzee.

Total absence of breasts (amastia) is a true agenesia, that is, total absence of the development of the milk anlage, which is a rare condition. It is usually accompanied by other malformations of the soft parts or bones. In addition to the cases collected by Deaver and McFarland, amastia has been observed by Fabre, Glos, Louria, Putzu Doneddu, Stiglbauer, Szczawinska and Velasco Blanco and Echegaray.

In this paper the discussion will be limited to the incidence, physiology and pathology of the supernumerary breast.

INCIDENCE

There are apparently some racial differences in the incidence of polymastia. The abnormality is of more frequent occurrence among Japanese women (5.19 to 6 per cent) than in the men (1.68 to 2.03 per cent), according to Iwai. For Chinese men the figure was given as 3.6 per cent by Takeya. It is also observed more frequently above the normal breast in the Japanese than in the white race, occurring above in approximately 70 per cent of the cases and below in 30 per cent. These figures are approximately reversed for white people.

Supernumerary breasts are unilateral or bilateral. If multiple, they usually occur in the milk line. Atypical locations have been described in great detail by Deaver and McFarland, who collected instances from the literature up to 1915, and by other observers.

One additional breast occurs in from 60 to 65 per cent of the cases, two in 30 to 35 per cent, three in 3.5 to 4 per cent and four in 1.5 to 2 per cent. It is clear, therefore, that the relative incidence of super-

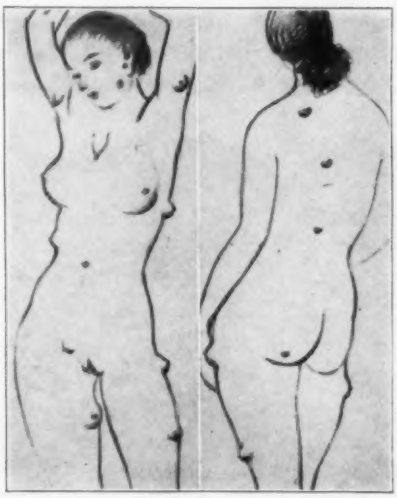

Fig. 2.—The location of "atypical" supernumerary breasts, schematically shown, as observed in females by different authors.

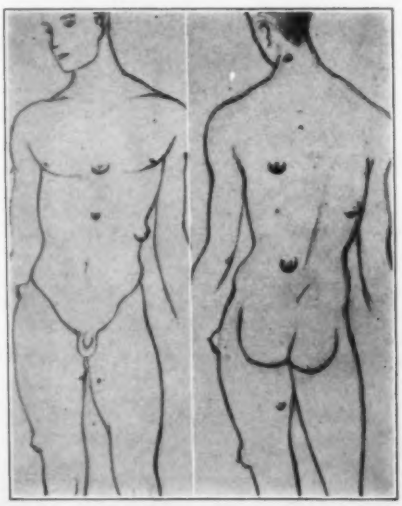

Fig. 3.—Location of "atypical" supernumerary breasts, schematically shown, as observed in men.

numerary breasts diminishes with the increase in the number of those organs observed in one person. There is reported a case of eight breasts in a male (Wiedersheim) and another of eight in a female (Dietrich).

Hirst observed nine in a colored woman, four of them being large enough to afford nursing and all secreting milk after childbirth. In Graham-Campbell's case there were ten breasts and nipples in a woman, and the four cephalic ones were equal in size and shape. The newborn child of this woman also had a supernumerary nipple, which supports the opinion of most observers that the condition is hereditary. Neugebauer observed a woman with ten breasts situated in the milk lines

Fig. 4.—Bilateral polythelia in the milk line beneath the breast.

Fig. 5.—Intra-areolar polythelia in a white woman.

which were all functional after parturition. In this case three pairs were situated above the normal breasts.

Aberrant breast tissue is observed relatively frequently and almost exclusively in the axillas. These masses are usually noted at pregnancy. But Schmidt-Tannwald observed such tissue, the size of a man's palm, beneath the clavicle of a woman. In my series there were 41 patients with aberrant breast tissue, all women and all with the tissue in the axillas. In 11 of the patients who were treated by surgical procedures the character of the tissue was proved by pathologic examination.

Polythelia is found with relative frequency. The figures vary widely according to different authorities. It occurs in equal numbers of persons in the two sexes, the incidence varying up to 6 per cent, although a range of from 14 to 23.3 per cent has been suggested by published figures. A conservative estimate of from 1 to 2 per cent seems to be more exact.

Unusual is the form of intra-areolar polythelia which may originate, according to Sutton, as the result of intrauterine division (dichotomy) of the developing breast or nipple. Though of rarer occurrence, polythelia may be confined to a single breast, two, three or more nipples

A Compilation of Atypical Cases of Supernumerary Breasts Observed by Various Authors

Location of Supernumerary Breasts	Number of Patients	Sex of Patient	Authors of Case Reports
Cheek	2	Female	Deaver and McFarland
Neck	1	Male	Holtz
Ear, tragus and helix	2	Female	Hug, Barth
Arm, upper part of left	1	Female	Sato
Thorax and abdomen (midline)	9	4 male, 5 female	Compiled by Deaver and McFarland
Shoulder	3	2 male, 1 female	Hoepfner, Scalzi, Klob
Back, lumbar region	9	5 male, 4 female	Compiled by Deaver and McFarland, Jaki
Pubic, inguinal region	10	4 male, 6 female	Compiled by Deaver and McFarland
Flank and hip	4	3 male, 1 female	Compiled by Deaver and McFarland
Thigh and Scarpa's triangle	9	5 male, 4 female	Testut, Steinborn and Mosig, Dietschy, Romiti, Sacasa, Cutore, Forster, de Cholnoky
Thigh and dorsolateral aspect	7	3 male, 4 female	Compiled by Deaver and McFarland
Buttock	1	Female	Compiled by Deaver and McFarland
Vulva	4	Female	Bergner, Purves, Mengert
Labium majus	1	Female	Bergner, Purves, Mengert
Labium minus	1	Female	Bergner, Purves, Mengert

having been thus noted; and report has been made of these supernumerary nipples on both breasts in the same person. One of my patients had such an intra-ocular polythelia, as shown in figure 5.

ATYPICAL LOCATIONS OF SUPERNUMERARY BREASTS

Supernumerary breasts develop regularly in the embryonic milk lines, but they may also be found, more rarely, at locations which are normal in certain other mammals. These atypical, "freak," aberrant breasts fundamentally arise on a foundation of misplaced embryonic anlage. Accepting the Geoffroy-Saint-Hilaire–Darwin theory, the observation of such abnormalities would prove the reversion to ancestral characteristics that is called atavism.

I have made a study of atypical cases observed by different authors and present the accompanying table.

HEREDITY

Klinkerfuss recorded a hereditary incidence through four generations, and Birkenfeld, among others, observed the condition in twins. By selective breeding in sheep, Bell succeeded in breeding out four functional supernumerary breasts in the offspring. He considered this proof of their hereditary character.

Though Astarte, the goddess of fertility, was represented as many breasted, and in spite of the popular belief that women with polymastia have multiple births, there is not sufficient evidence to support this expectancy. Apparently polymastic women do not show a tendency to bear twins more frequently than do other women.

CLINICAL ASPECTS

Kajava classified congenital supernumerary breasts as:

(1) complete breast with nipple, areola and gland tissue;
(2) supernumerary breast without areola but with nipple and gland tissue;
(3) supernumerary breast without nipple but with areola and gland tissue;
(4) aberrant gland tissue without nipple and areola;
(5) pseudomamma with nipple and areola but without gland tissue (the breast tissue is replaced by fat);
(6) polythelia (the presence of nipples only);
(7) polythelia areolaris (the areola only),
(8) polythelia pilosa (only a patch of hair present).

Supernumerary breasts usually appear as polythelia or pseudomamma. Complete supernumerary breasts are exceptional. Perfect supernumerary breasts may secrete milk during the period of lactation and undergo the cyclic changes of the normal breast. Tumors may develop in them.

An interesting case was reported by Bergner. A 27 year old woman at repeated pregnancies acquired a cyst on the right labium, which at one time yielded 250 cc. of what proved, on analysis, to be milk. Such findings were also described by Purves and Mengert in a patient in whom the labium minus was involved. McFarland pointed out that the appearance of a supernumerary breast in this location is another form of atavism, as in the cetaceae all mammary rudiments disappear with the exception of one in each labium majus.

My observation of a well developed complete breast in Scarpa's triangle (on the right thigh) seems to be unique among available recorded cases and comparable only to a case of pseudomamma in the same location in a man reported by Forster (fig. 6). A similar case

was observed in which a man had a pseudomamma on the inside of the right thigh where the milk line ends.

Our case may be summarized as follows:

E. C., a woman aged 42, complained of a lump on her right thigh which she said she had had as long as she could remember. It increased in size during pregnancies, was not painful and did not secrete. Menstruation had begun at the age of 13 and was of the regular twenty-eight day type. She had had two children and two miscarriages. Examination revealed a well developed breast (like that of a girl of 16) with a large well developed nipple located on the inner aspect of the upper part of the right thigh (figs. 7 and 8). On palpation it had the character of somewhat firm but normal breast tissue. The patient returned for examination two months later, complaining of occasional lancinating and pricking pain in this breast, which was more marked before menstruation. Mastectomy was advised but refused.

Fig. 6.—Pseudomamma in a man (Forster).

It is of clinical interest that these malformations may annoy the bearer by their physiologic function and may give rise to benign and malignant tumor formation. Those located in the axilla most frequently give rise to complaints (fig. 9). The woman may become aware of this misplaced breast during pregnancy and lactation, when swelling and milky discharge (if ducts are present) occur. The swelling is accompanied by pain, sometimes severe, usually in both axillas. In some cases the aberrant gland tissue is connected by a duct with the normal breast, and the secretion may be discharged through the main channels. In such a case subjective complaints will be less. If no such communication exists, the swelling and pain will be more marked. These round or often spindle-shaped or oval swellings are very tender, appearing usually between the second and the fourth day after delivery and increasing in

Fig. 7.—Lateral view of a complete supernumerary breast at Scarpa's triangle on the right thigh of a white woman.

Fig. 8.—Direct view of supernumerary breast shown in figure 7. Note the well developed nipple and areola.

size up to the fifth or seventh day. If a duct is present, there may be secretion of colostrum or milklike fluid. (According to Seitz, these functional tumors are not true supernumerary breasts but large sweat glands of the axilla undergoing the described changes under the stimulus of pregnancy.) There is no ground for surgical intervention in such cases unless infection has taken place or unless persistent secretion keeps the patient's clothing wet and the patient desires to have the "tumor" removed.

DIFFERENTIAL DIAGNOSIS

This condition must not be confused with the relatively frequent prolongation of a tail of the normal breast, which gives the impression, on superficial examination, of being aberrant breast tissue.

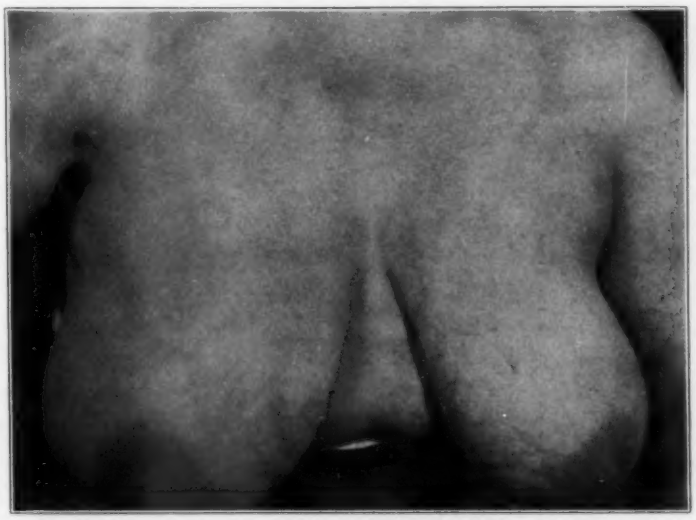

Fig. 9.—Bilateral aberrant breast tissue in the axilla.

Aberrant breast tissue is frequently diagnosed as lipoma, since it is sometimes totally composed of fat tissue. More often it appears as a soft, lobulated fatty tumor enclosing a small core of breast tissue, which may be only a few millimeters in diameter. In the cases of 4 of my 11 patients who were operated on the condition was diagnosed clinically as lipomas, and in these cases the pathologic report was aberrant breast tissue. The patients were women about 25 years of age who did not present characteristic symptoms, such as cyclic changes. The report of 1 of these cases follows:

F. H., a woman 31 years of age, had noticed a small lump in the left axilla at the time of childbirth, four years before the examination. During the last year persistent swelling and lancinating pain had been present. Examination revealed a soft, lobulated, well circumscribed tumor about 8 cm. in diameter. A clinical

diagnosis of lipoma was made, and the tumor was excised. Pathologic examination showed low grade inflammation with cystic changes of the aberrant breast. Postoperative recovery was normal, and the results of follow-up examination were negative.

From the diagnostic point of view, supernumerary breast tissue may be confused with other benign tumors, as in 2 of my cases. In 1 of these the growth proved to be a fibroma (fig. 10) below the normal breast in the milk line; in the other, a lipoma in the axilla. The latter growth impressed me as being a functional chronic mastitis, accompanied by occasional menstrual pain, in a woman 36 years of age. In my opinion the clinical diagnosis should always be fortified by a pathologic report.

The diagnosis of supernumerary breast tissue is confirmed if the patient states that the swelling appeared simultaneously with development of the normal breast at puberty or that it appeared at the time of pregnancy or childbirth. It may follow the cyclic changes of the normal breast; that is, there may be premenstrual swelling with some tenderness.

Fig. 10.—A fibroma which resembles a supernumerary breast.

TUMOR FORMATION IN THE SUPERNUMERARY BREAST

Tumor formation is observed in the supernumerary breast when glandular tissue is present. It is relatively most frequent in the aberrant breast tissue. Occasionally cystic degeneration in such breasts has been observed (Noronha).

Fibroadenoma was observed in 1 of my cases:

T. S., a 25 year old woman, complained of a lump in the right axilla which had appeared one and a half years before. Occasional pain was present, and the tumor slowly increased in size. Six months after its discovery the growth was removed, and a year later in the follow-up examination recurrence was noted.

Examination showed a smooth, oblong, movable subcutaneous mass, 3 by 3.5 cm. in diameter, slightly elevated, firm, slightly lobulated and not tender on palpation. By elliptic excision the old scar with the multilocular white tissue growth was removed. The mass gave the impression of being supernumerary breast tissue. The pathologic examination showed intracanalicular fibroadenoma of the supernumerary breast. This case illustrates the importance of thorough dissection on the first operation, in order to prevent recurrence.

White excised a fibroadenoma from one of two bilateral supernumerary breasts located beneath the normal breasts. Palumbo found one fibroadenoma in the axilla, with a coincident myxosarcoma of the breast. Friedel reported a case of fibroadenoma in the vulva, and Roth observed cystic fibroadenoma in the same location, both developing in supernumerary breast.

Carcinomatous degeneration was observed in the aberrant axillary breast by Giacobbe and Matti and in aberrant breast tissue beneath the clavicle by Ravdin. Erdmann observed it in his 3 cases, in 1 of which the patient was a man of 26. Patel, Montemartini and Greene have reported carcinoma of the vulva developing in supernumerary breast in that location. In 1929 Razemon and Bizard collected 43 cases; 28 of the growths were in the axilla, 10 in the sternal region and 5 under the clavicle; in addition, there were 23 benign tumors in the supposedly supernumerary breasts, of which 19 were in the axilla.

On the other hand, Biancheri found only 31 cases in the literature as of 1932, some of which might be duplications of those reported by Razemon and Bizard. I am under the impression that many such cases should be classified as instances of "carcinoma of the breast" unless direct connection between the normal breast and the aberrant tissue can be eliminated with certainty.

The relatively rare observations of benign or malignant tumor formations in these frequently occurring anomalies give the impression that the anomalies are essentially harmless.

TREATMENT

The study and observation of the supernumerary breast are interesting because they give a clue to the line of human descent and form an interesting chapter of comparative anatomy, but a survey of all the cases presented in the literature leads to the conviction that it is a harmless malformation. Therefore, unless the breast has an inconvenient function (such as a discharge) or an inconvenient location (for example, at the axilla), or unless the patient has subjective symptoms (such as a feeling that she is like an animal) or there is a tumor formation present, no surgical intervention is indicated.

SUMMARY

The development of the supernumerary breast may be considered a reversion to remote ancestral characteristics (atavism).

Accessory breasts are commonly observed (1 to 2 per cent) in both sexes and are usually situated in the milk lines. They are also rarely found at atypical locations where lower mammals have normal breasts. A compilation of atypical supernumerary breasts in human beings is reported.

Two new cases of unusual supernumerary breasts are described, 1 of a complete breast in a female and the other of a pseudomamma in a male; in both cases the growth was situated on the inner aspect of the right thigh. One case of infrequently observed intra-areolar polythelia in a multipara is also described. Two tumors of the accessory breasts surgically treated proved, on pathologic examination, to be chronic mastitis and fibroadenoma, respectively. No malignancy was found in any of the 41 cases of functional supernumerary breasts.

No operation is indicated for these anomalies unless there are "psychologic" symptoms or unless their location or tumor formation warrants removal.

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EPIDURAL HEMANGIOMA ASSOCIATED WITH HEMANGIOMA OF THE VERTEBRAE

REPORT OF A CASE

ROLLA G. KARSHNER, M.D.

CARL W. RAND, M.D.

AND

DAVID L. REEVES, M.D.

LOS ANGELES

In the experience of Aschoff,[1] Kaufman[2] and others, hemangiomas of the vertebral column have been encountered rarely. In 1927, however, Makrycostas[3] was able to describe 12 cases which he collected during the routine autopsy work of Erdheim's laboratory. He stated the opinion that the uncommon occurrence of compression of the spinal cord with such lesions probably explains the infrequency of reports of the condition in the literature. No neurologic manifestations were recorded in the 12 cases which he described. He observed that vertebral hemangiomas are most common in late adult life, are irregular in their distribution, are most frequently multiple and are ordinarily discovered in the lower dorsal and lumbar vertebrae.

In 1928 Töpfer[4] more than confirmed the impression of Makrycostas that hemangiomas of the vertebral column are not so much a pathologic as a clinical rarity. He sagittally sectioned the vertebral columns of 2,154 cadavers at necropsy, and in 257, or 11.93 per cent, found angiomas of the vertebrae, although in 4 cases tumors were in the spinous processes and in 3 others in the arch. Incidentally, in 9 of the necropsies angiomas were discovered in the sternum; in 3, in the femur; in 3 others, in the skull, and in 4 others, in the liver. None of the tumors

From the Children's Hospital.

1. Aschoff, L.: Pathologische Anatomie, ed. 6, Jena, Gustav Fischer, 1923, vol. 2, p. 226.

2. Kaufman, E.: Lehrbuch der speziellen pathologischen Anatomie für Studierende und Aerzte, Leipzig, Walter de Gruyter & Co., 1922, vol. 1, p. 937.

3. Makrycostas, K.: Ueber das Wirbelangiom, -lipom und-osteom, Virchows Arch. f. path. Anat. **265**:259, 1927.

4. Töpfer, D.: Ueber ein infiltrierend wachsendes Hämangiom der Haut und multiple Kapillarektasien der Haut und inneren Organe: Zur Kenntnis der Wirbelangiome, Frankfurt. Ztschr. f. Path. **36**:337, 1928.

produced any known symptoms, which is readily understood when it is realized that in no case did they extend into the spinal canal. As might have been expected, variation in size of the growth from complete involvement of the vertebral body to a small tumor the size of a pea occurred. In 41 cases the angiomas were associated with lipomatous formation.

In 1929 Bailey and Bucy [5] pointed out that although cavernous hemangiomas of the vertebrae present a characteristic roentgen picture which can be diagnosed, in none of the 11 cases reported in which there were symptoms referable to the spinal cord was the diagnosis made either before operation or before necropsy.

That epidural hemangiomas seldom occur is evident from the fact that Johnston [6] in 1938 was able to collect only 14 cases. He apparently overlooked 1 reported by Bucy [7] and 2 of Dott's mentioned by Bucy, which bring the total to 17. Though there may be others which have been neglected, the number remains small. Instances of hemangiomas of the vertebrae associated with hemangiomas of the spinal cord and its membranes have been reported only exceptionally. In 1 such case an unsuccessful operation was done by Elsberg (Globus and Doshay [8]). In many ways the following case, which was observed at the Children's Hospital of Los Angeles and in which the correct diagnosis was made preoperatively, seemed similar. To our knowledge the growth described here is the third vertebral hemangioma to be treated successfully by operation. It is, moreover, the only hemangioma of the vertebrae with compression of the spinal cord diagnosed preoperatively as such.

REPORT OF CASE

Schoolboy 14 years of age. Numbness of the feet and unsteadiness of gait Dec. 15, 1938, becoming progressively worse. Sensory level at eighth thoracic area with complete spinal subarachnoid block and highly elevated values for protein. Pain to palpation over seventh and eighth thoracic spines. Several scattered pigmented hemangiomatous nevi especially in the region of fifth to ninth thoracic dermatome. Preoperative diagnosis of epidural vertebral hemangioma confirmed by laminectomy and histopathologic study. High voltage roentgen therapy. Recovery.

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5. Bailey, P., and Bucy, P. C.: Cavernous Hemangioma of the Vertebrae, J. A. M. A. **92**:1748 (May 25) 1929.

6. Johnston, L. M.: Epidural Hemangioma with Compression of the Spinal Cord, J. A. M. A. **110**:119 (Jan. 8) 1938.

7. Bucy, P. C.: Blood Vessel Tumors of the Spinal Canal, S. Clin. North America **12**:1323 (Oct.) 1932.

8. Globus, J. H., and Doshay, L. J.: Venous Dilatations and Other Intraspinal Vessel Alterations, Including True Angiomata with Signs and Symptoms of Cord Compression, Surg., Gynec. & Obst. **48**:345 (March) 1929.

Clifford F., a schoolboy aged 14, was admitted to the Children's Hospital on Jan. 21, 1939. He had been well until noon of Dec. 15, 1938. At this time he became unsteady on his feet, his right leg being noticeably more ataxic than his left. A few nights later he realized that he was unable to feel the bedclothes normally over his lower extremities, and he also noticed that his feet felt rather numb. This numbness became progressively more pronounced, so that within a week of his admissioin to the hospital it had extended up to his waist. A few weeks after the onset of his illness he realized that his legs felt stiff and that he had difficulty in relaxing them. This spasticity increased, as did the ataxia, so that a few days prior to hospitalization he was able to walk only with difficulty. A few weeks after the onset of his illness he noticed occasionally a shocklike sciatic pain down both thighs when he sat up suddenly. Occasionally this was limited

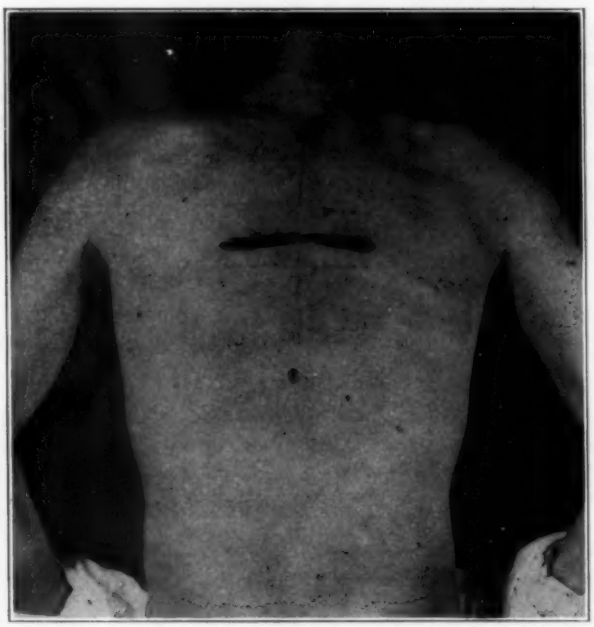

Fig. 1.—Photograph taken postoperatively of the patient's back, showing the scattered pigmented nevi. The pencil marking on the skin is over the involved area of the vertebrae for the roentgen therapy.

to one side. He failed to notice any accentuation of his symptoms on coughing or straining, and they were unrelated to any injury to his back. His family and past history were entirely noncontributory.

Examination revealed him to be well developed and well nourished. He was mentally alert and cooperative. General physical examination was without positive result except that on the back, especially in the region of the fifth to the ninth thoracic dermatome, several scattered pigmented hemangiomatous nevi were found (fig. 1). Tenderness to palpation was also noted over the seventh and eighth thoracic spinous processes. Neurologic examination revealed no significant abnormality of the cranial nerves. Although tests for coordination were performed normally with the upper extremities, there was considerable ataxia when these were carried out with the lower extremities. The Romberg reaction was positive,

and the gait was ataxic, the patient walking spastically on a wide base. A definite level of hypesthesia to light touch, pinprick, heat, cold and vibration, corresponding to about the eighth or the ninth thoracic segment with suggestive sparing of the sacral segments, was obtained. Sensory impairment seemed a little more marked on the right than on the left. The sense of position was completely impaired in the lower extremities. The abdominal and epigastric reflexes were not obtained; the Babinski sign and allied signs were strongly positive bilaterally. The biceps, triceps and radial reflex and finger jerk were bilaterally hypoactive. An abortive patellar reflex and a sustained ankle clonus were obtained on each side, and both legs were spastic. Compression of the jugular vein caused no sciatic pain or accentuation of the symptoms. No disturbance of the sphincters was evident at this time, and the vasomotor reaction was only moderately accentuated.

Roentgenograms of the thoracic vertebrae taken on Jan. 17, 1939, showed decalcification of the body of the seventh dorsal vertebra, with loss of the pedicle, and a shadow in the anteroposterior projection which was felt to be due to a

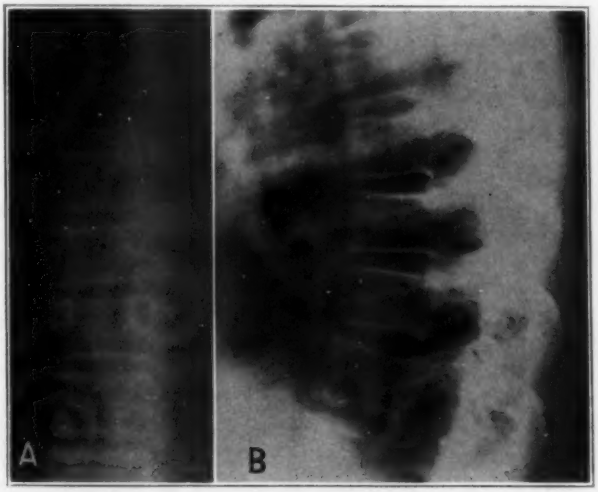

Fig. 2.—*A*, anterior view of the thoracic vertebrae, showing the vertical striations and loss of the normal homogeneous structure of the seventh thoracic vertebral body. *B*, lateral view of the same structures.

tumor. Other roentgenograms, taken on January 19 (fig. 2), were sufficiently clear to lead to the diagnosis of hemangioma of the seventh vertebra. The parallel vertical striations of the vertebral body with loss of the normal homogeneous structure, so characteristic of the picture, though not as prominent as is often seen, were sufficiently evident to be diagnostic.

Examination of the blood on January 13 revealed a hemoglobin content of 81 per cent, a red cell count of 4,200,000 per cubic millimeter and a white cell count of 6,550 per cubic millimeter, with normal-appearing platelets. Urinalysis on January 14 gave negative results for albumin, sugar and Bence Jones protein. Microscopic examination disclosed no red blood cells or casts. A lumbar puncture by Dr. J. C. Welch on January 16 revealed complete block; the spinal fluid gave a negative Wassermann reaction, contained 4 cells per cubic millimeter and had a total protein content of 260 mg. per hundred cubic centimeters.

In view of the appearance of the roentgenograms, the level of hypesthesia, the scattered papillary hemangiomatous nevi and the other positive findings, a preoperative diagnosis of vertebral hemangioma involving the region of the seventh thoracic vertebra with compression of the spinal cord from an epidural hemangioma was made.

A midthoracic laminectomy was performed on January 23, and, as had been anticipated, the skin and underlying tissues were very vascular. The bone of the removed sixth, seventh and eighth spinous processes and laminas was soft and infiltrated with tumor. Hemorrhage was so profuse that anything but partial removal of the vascular extradural hemangioma was precluded. No attempt was made to open the dura, and in view of the findings there seemed no reason to do so. Bleeding was controlled eventually by means of the electrocautery and pieces of muscle. As profuse hemorrhage had been anticipated, a transfusion of 600 cc. of citrated blood was given shortly after the operation was undertaken. Closure was carried out in the usual manner, with extradural drainage by means of a Penrose drain brought out through a separate stab wound to one side of the incision. The patient's recovery from the procedure was uneventful, and the wound healed without incident. On the seventh postoperative day, although the sensory level was still present, the boy believed that sensation had improved considerably. He was able to move his legs better and was not so troubled with spasticity. His sense of position, however, was still much impaired. High voltage roentgen therapy was started on the thirteenth postoperative day, and fifteen treatments, totaling 3,000 roentgen units, were subsequently given. On the nineteenth postoperative day the sensory level previously demonstrable had disappeared, and the spasticity had markedly improved. He was still ataxic, however, with bilateral ankle clonus and a bilaterally positive Babinski sign. The sense of position of the lower extremities was still impaired, and the Romberg sign was strongly positive. By the twenty-eight postoperative day, although he was able to walk, he continued to be ataxic, a condition which had improved only slightly at the time of his discharge, on March 3 (the thirty-ninth postoperative day). When he was seen again, on April 9, about seventy-seven days after the operation, he was quite well. He was going to school again, riding his bicycle, and was able to run and walk without any indication of ataxia.

Pathologic Report.—The gross and microscopic specimens were examined by Dr. Lucile R. Anderson, of the Children's Hospital. The specimen consisted of a combined piece of bone and cartilage measuring 3.9 cm. in length and up to 1.2 cm. in width, with a piece of dark red, hemorrhagic-appearing soft tissue measuring 1.8 by 2 by 1 cm. and containing spicules of cancellous bone and a portion of attached fatty tissue. The sectioned material revealed plexuses of endothelium-lined channels filled with blood lying in a stroma of loose connective and fatty tissue (fig. 3 *A*). Occasional plasma cells and round cells and also a few bone spicules were found in the connective tissue. The picture was felt to be typical of capillary or cavernous hemangioma. A longitudinal section of the specimen of bone showed replacement of the cancellous bone marrow with hemangiomatous tissue similar to that observed in the soft parts (fig. 3 *B*).

COMMENT

From his experience with vertebral hemangiomas Bucy [9] recovered no information concerning the etiology of these lesions and felt unable

9. Bucy, P. C.: The Pathology of Hemangioma of Bone, Am. J. Path. **5**:381 (July) 1929.

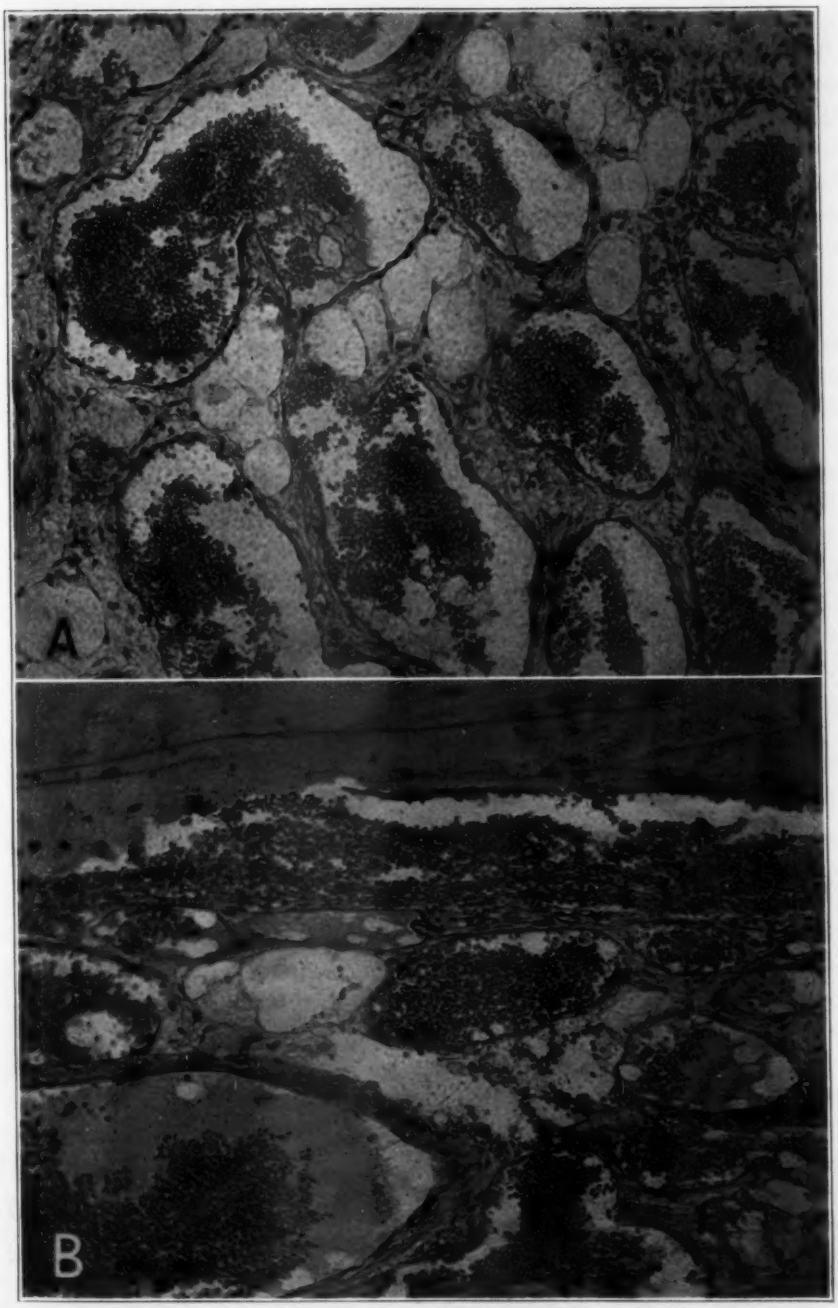

Fig. 3.—A, photomicrograph of the epidural hemangioma, revealing plexuses of endothelium-lined channels filled with blood corpuscles lying in a stroma of loose connective and fatty tissue. *B,* similar photomicrograph, taken through a specimen of the removed bone.

to decide whether they are neoplasms or vascular malformations. Although they differ undoubtedly from the hemangioblastomas in being relatively benign, slow in growth and not metastatic, they are generally distinguished from mere dilatation of capillaries or venules by their independent growth without regard to the laws governing the distribution of such vessels, and for this reason varicosities, aneurysms and redundant granulation tissue are usually excluded. Ordinarily, hemangiomas are divided into the simple and the cavernous form. The simple, or telangiectatic, form occurs most commonly in the skin as nevi in which the abundant though widened capillaries maintain fairly well their form as tubes with parallel walls. In the cavernous type the character of erectile tissue is approached, with widely dilated, irregular blood spaces opening abundantly into one another but separated by a variable amount of connective tissue. Often it is not clearly apparent where the line of division can be drawn between these two types. According to Bucy [9] there is no microscopic evidence of malignancy. Mitotic figures are never seen, and the stroma is acellular, loose and fibrous. He expressed the belief that the vertebral hemangioma is a benign, slowly growing tumor mass which, as a result of its presence and growth, produces a characteristic reaction in the bone in which it arises or which it invades. Such changes in the bone, he concluded, are only secondary reactive phenomena.

Most of the accumulating evidence suggests a congenital origin for these tumors. Although the cavernous form usually becomes apparent during the second or third decade, this does not preclude the possibility of its embryonal origin; in fact, in many cases the cavernous form has originated from preexisting birth marks. In a study of 645 patients, Fitzwilliams [10] discovered that 83.2 per cent of the hemangiomas had been observed at birth and that an additional 12.8 per cent had appeared within the first three years of life. In 16 per cent of 108 cases of hemangioma reviewed by Patton [11] a history of a similar condition occurring in the family was obtained.

According to Cobb,[12] the subject of the metameric distribution of nevi was first taken up in 1863 by Baerensprung,[13] who described their topographic distribution and drew attention to their development in definite connection with territories of cutaneous innervation. Because the cutaneous alteration consisted of hypertrophy of the elements in

10. Fitzwilliams, D. C. L.: The Etiology of Naevi: Nerve Influence in Their Causation, Brit. M. J. **2**:489, 1911.

11. Patton, M. M.: Pathology and Treatment of Hemangioma Cavernosum, Northwest Med. **5**:121 (May) 1913.

12. Cobb, S.: Hemangioma of the Spinal Cord, Ann. Surg. **62**:641 (Dec.) 1915.

13. von Baerensprung, F. W.: Naevus unius lateris, Ann. d. Char.-Krankenh. **11**:91, 1863.

which the peripheral nerves terminated, that is, the pigmented layer of the skin containing the free nerve endings and the blood vessels of the papillary layer also receiving nerve filaments, he stated the belief that the lesion is a congenital one of the spinal ganglions. Etienne,[14] who reviewed the subject in 1897, came to a more or less similar conclusion and felt that a nevus represents an intrauterine nerve lesion. It was not, however, until the publication of Cushing's [15] article in 1906 that it was first suggested that organs other than the skin but in the same segment of nerve distribution could be similarly affected. Cushing [15] included 3 of his own with 3 from the literature in which facial hemangiomas were associated with vascular tumors of the cerebral meninges, and since that time facial hemangiomas and associated intracranial vascular anomalies have been observed and reported frequently.

Although this has been true for facial hemangiomas with associated intracranial vascular anomalies, little can be found concerning such hemangiomas of the trunk associated with intraspinal vascular anomalies. Cobb [12] apparently was the first to report a condition of this sort. In his case hemangiomas of the skin occurred in the same dorsal segment in which an epidural hemangioma was uncovered at operation. The presence of the cutaneous hemangiomas associated with symptoms and signs of compression of the cord at the same level led to a correct preoperative diagnosis of intraspinal hemangioma. As a result of his experience with this case, Cobb [12] concluded that cutaneous nevi are at times diagnostically valuable, when the central nervous system is involved segmentally. He also expressed the opinion that congenital vascular tumors arise from a developmental fault of the central nervous system, which explains their possible occurrence in any of the organs innervated by filaments from that neuromere.

Rand [16] was the second to report a case in which a nevus of the skin of the back led to a preoperative diagnosis of hemangioma of the cord which was confirmed subsequently at operation. As far as can be determined, Johnston [6] was the third to report a condition of this kind, and we (this paper) are the fourth.

Since the publication of the report by Globus and Doshay,[8] 7 additional cases of epidural hemangiomas have been reported, bringing the total to 17. In 10 of these laminectomy and removal of the tumor resulted in partial or complete recovery and in 1 case in death. In 6 instances laminectomy was not attempted. Our case raises the total

14. Etienne, G.: Des naevi dans leur rapports avec les territoires nerveux, Nouv. iconog. de la Salpêtrière **10**:263, 1897.

15. Cushing, H.: Cases of Spontaneous Intracranial Hemorrhage Associated with Trigeminal Nevi, J. A. M. A. **47**:178 (July 21) 1906.

16. Rand, C. W.: Hemangioma of the Spinal Cord, Arch. Neurol. & Psychiat. **18**:755 (Nov.) 1927.

number of epidural hemangiomas of the spinal cord to 18 and the total number of those treated by laminectomy with recovery to 11.

As far as can be determined, Hitzrot [17] in 1917 first published and described a roentgenogram of a bone hemangioma. In 1926 Perman [18] and Gold [19] published roentgenograms and descriptions which brought forth for the first time the peculiarities evident in roentgenograms of vertebral hemangiomas. These were emphasized further in the excellent papers of Bailey and Bucy [5] and Bucy and Capp.[20] They found the picture one of irregular absorption of bony trabeculae and thickening of the remaining vertical trabeculae with resulting parallel vertical striations in the bodies of the vertebrae and loss of the normal homogeneous bony structure. Not uncommonly these abnormal trabeculations extended into the vertebral arches and laminas and involved more than one body. Because of the superimposed sternum, heart and mediastinal structures, the anteroposterior view fails to show the osseous changes as well as does the lateral view, which usually is diagnostic.

In 1929 Bailey and Bucy [5] collected 10 cases of cavernous hemangioma of the vertebrae producing symptoms of compression myelitis and added 1 of their own. Laminectomy was performed in 5 of these, with death from shock and hemorrhage in the cases observed by Gold, Elsberg (cited by Globus and Doshay [8]) and Guillain, Decourt and Bertrand.[21] Recovery resulted from the procedure in the cases observed by Perman [18] and by Bailey and Bucy,[5] although in both cases the patient's condition became critical because of shock and hemorrhage. It seems obvious, therefore, that laminectomy in these cases is a dangerous procedure, and preparation for the treatment of shock and hemorrhage is necessary. It is not unlikely that some of the deaths previously reported as following laminectomy were the result of unnecessarily enthusiastic surgical efforts. Not only does any attempt to open the dura seem unwise in these cases, but any effort to obtain complete removal of an underlying epidural hemangioma is ordinarily as futile as it is unreasonable.

The use of roentgen therapy alone in cases of compression myelitis seems not only inadequate but hazardous, for irreparable damage to the

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17. Hitzrot, J. M.: Hemangioma Cavernosum of Bone, Ann. Surg. **65**:476 (April) 1917.

18. Perman, E.: On Haemangiomata in the Spinal Column, Acta chir. Scandinav. **61**:91, 1926.

19. Gold, E.: Von den Wirbelveränderungen im Falle eines Hämangioms an der Dura spinalis, Arch. f. klin. Chir. **139**:729, 1926.

20. Bucy, P. C., and Capp, C. S.: Primary Hemangioma of Bone with Special Reference to Roentgenologic Diagnosis, Am. J. Roentgenol. **23**:1 (Jan.) 1930.

21. Guillain, G.; Decourt, J., and Bertrand, I.: Compression médullaire par angiome vertébral, Ann. de méd. **23**:5 (Jan.) 1928.

cord may occur before any beneficial effect can be anticipated. So far it has not been tried sufficiently to enable one to determine whether it would be advisable during the early stages of compression should the diagnosis be made and the patient kept under observation. According to Bucy and Capp,[20] Perman's [18] patient was in perfect health more than three years after laminectomy and postoperative roentgen therapy. Although the value of its use in these cases is uncertain, we believe that postoperative roentgen therapy is indicated and have given it to the patient in the present case, whose subsequent course will be followed with interest.

SUMMARY AND CONCLUSIONS

Hemangiomas of the vertebral column are not so much a pathologic as a clinical rarity. The present case is the twelfth in which such a condition caused compression myelitis, the first in which it was diagnosed preoperatively and the third in which it was successfully treated by operation. It is also one of the exceptional cases of vertebral hemangiomas associated with epidural hemangioma; the eighteenth case of epidural hemangioma of the spinal cord reported, and the eleventh such case in which the patient was cured after a laminectomy. Peculiarly, it is also the fourth case of hemangiomatous nevi of the skin occurring in the same dorsal segments as the epidural hemangiomas.

Whether vertebral and epidural hemangiomas represent neoplasms or vascular malformations remains a question. They are different from hemangioblastomas, relatively benign, slow in growth and not metastatic. Most of the accumulating evidence suggests a congenital origin.

With segmental involvement of the central nervous system, cutaneous nevi are diagnostically important.

As has been emphasized by Bucy and others, roentgenograms of the vertebrae reveal diagnostic peculiarities when the bone is involved by hemangiomas, particularly parallel striations in the vertebral bodies and loss of the normal homogeneous bony structure.

The high percentage of deaths following laminectomy in these cases shows that the procedure is a hazardous one, and preparations for the treatment of shock and hemorrhage should be made. It is suggested that the high mortality may have been the result of unnecessarily enthusiastic surgical efforts.

Although high voltage roentgen ray therapy is recommended as a postoperative measure, it would seem inadequate and hazardous to use such treatment alone when there is compression myelitis, for irreparable damage to the cord may occur before any beneficial effect can be anticipated.

PROTRUDED INTERVERTEBRAL DISK

REPORT OF A CASE; NOTE ON A POSSIBLE INFLAMMATORY ETIOLOGIC FACTOR (CIRCUMSCRIBED ARACHNOIDITIS)

GILBERT C. ANDERSON, M.D.
AND
ERWIN WEXBERG, M.D.
NEW ORLEANS

Protrusion of the intervertebral disk as the result of trauma was first mentioned by Virchow [1] in 1857, though it was not until more than fifty years later that Goldthwaite [2] pointed out its clinical significance. At almost the same time, Middleton and Teacher,[3] of Glasgow, Scotland, reported the full postmortem observations in such a case and correlated the clinical symptoms with the pathologic changes revealed at necropsy.[4] Since then numerous cases have been reported in the literature, and the various aspects of the condition have been thoroughly discussed. The latest and one of the most extensive of these reports is an analysis by Love and Walsh [5] of 100 cases in which operation was performed at the Mayo Clinic.

Since protrusion of the intervertebral disk is no longer regarded as rare or even as very unusual, the report of a single case demands some

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From the Departments of Surgery and Neuropsychiatry of the School of Medicine of Louisiana State University and from the Charity Hospital of Louisiana at New Orleans.

1. Virchow, R. L. K.: Untersuchungen über die Entwicklung des Schädelgrundes im gesunden und krankhaften Zustande und über den Einfluss derselben auf Schädelform, Gesichtsbildung und Gehirnbau, Berlin, G. Reimer, 1857.

2. Goldthwaite, J. E.: The Lumbo-Sacral Articulation: An Explanation of Many Cases of "Lumbago," "Sciatica," and Paraplegia, Boston M. & S. J. **164**:365, 1911.

3. Middleton, G. S., and Teacher, J. H.: Injury of the Spinal Cord Due to Rupture of an Intervertebral Disk During Muscular Effort, Glasgow M. J. **76**:1, 1911.

4. W. E. Dandy (Loose Cartilage from Intervertebral Disk Simulating Tumor of Spinal Cord, Arch. Surg. **19**:660 [Oct.] 1929) reported 2 cases of "loose cartilage from intervertebral disk," the first cases of this kind in which the cartilage was detected at operation when tumors of the vertebrae were suspected. Sequestration of the protruded mass of cartilage obviously represents an advanced stage of simple protrusion, which is the more frequent finding.

5. Love, J. G., and Walsh, M. N.: Protruded Intervertebral Disks: Report of One Hundred Cases in Which Operation Was Performed, J. A. M. A. **111**:396 (July 30) 1938.

explanation. The justification is that this special case brings out clearly a point to which no great attention has been paid, namely, the possibility that an associated inflammatory process rather than protrusion of the disk per se may be responsible for the clinical symptoms.

REPORT OF A CASE

J. L., a white laborer 42 years old, was admitted to the Charity Hospital on April 27, 1938, complaining of dysuria and of pain in both legs. He had been entirely well until two months before admission, when he lifted a sack of sugar weighing about 200 pounds (90 Kg.) and was aware as he did so that he had twisted his body. Immediately he felt a sharp, shooting pain in his back, which some hours later radiated down the posterior aspect first of the right and later of the left lower extremity. Lifting such weights was part of his work and had never before caused any discomfort or pain.

The pains described recurred at irregular intervals without change in their character until he was admitted to the hospital. Weakness soon developed in both legs, and standing became impossible. Two weeks before he entered the hospital he had difficulty in urination, and the act finally became impossible without straining. Function of the bowel was not disturbed, but a few days after the urinary symptoms developed he noticed loss of sensation about the anus.

The previous history was without incident except for an appendectomy in 1927. There was no history of venereal infection. The patient said that he smoked moderately but rarely touched alcohol.

Physical examination revealed no deviation from the normal except for slight dyspnea and mild edema of both ankles. Neurologic examination also gave entirely negative results except for the following findings in the lower extremities:

All passive movements were normal, and the hip and knee joints could be moved normally on both sides. The strength of the right extremity was markedly and that of the left moderately reduced. The patient could stand and walk only if strongly supported. Coordination was normal. There was hypesthesia for all qualities in the left perianal area and on the left side of the genitalia (segments S_4 and S_5). There was no tenderness of the nerve points. Lasègue's sign was absent. The patellar reflexes were positive (2 plus) and equal. The achilles reflex was absent on both sides. The plantar reflex was positive and equal on both sides. Babinski's and Oppenheim's signs were absent.

Spinal puncture between the third and the fourth lumbar vertebra yielded clear fluid under 1 mm. of pressure, which rose to 3 mm. when the jugular veins were compressed. The reaction for globulin was plus 4, and each cubic millimeter contained 200 cells. The mastic curve was 0012333330. The Wassermann reaction was negative, and urinalysis showed no abnormalities.

Roentgen examination of the pelvis and of the lumbar portion of the spine showed no evidence of bony erosion. The bodies of the lower lumbar vertebrae showed hypertrophic changes. Twenty-five days after admission, myelographic examination after injection of iodized poppyseed oil into the cisterna showed that the oil was apparently arrested at the midportion of the third lumbar vertebra; all of it had not gravitated to this level. Anteroposterior and lateral views of the lumbar portion of the spine taken on the next day showed the oil still arrested at this point. No characteristic deformity could be made out in any of the pictures. A diagnosis was made of a possible tumor of the cauda equina at the level of the third lumbar vertebra, and laminectomy was advised.

Operation (by G. C. A.) was done thirty-six days after admission with the patient under general anesthesia. The spines and laminas of the second and of the third lumbar vertebra were removed. The exposed dura looked normal, but no pulsation was visible until the spine and lamina of the first lumbar vertebra had been removed; then pulsation was noted in the upper angle of the space. When the dura was opened, spinal fluid and iodized oil promptly gushed out. No tumor or obstruction could be seen, and a grooved director passed 5 inches (12.5 cm.) up the canal without encountering any resistance. When the strands of the cauda equina were separated, a slight protrusion of the intervertebral disk could be detected at the lower portion of the wound, probably the fourth lumbar vertebra. The protrusion was so slight that it seemed entirely insufficient to account for the severe clinical symptoms. It was removed with a curet after the dura had been split anteriorly. The dura was closed posteriorly with silk, and the wound was sutured in layers about a rubber dam drain.

The postoperative diagnosis was herniation of the fourth lumbar intervertebral disk.

For five days after the operation the patient complained of pains in his legs; by the eighth day the pains had entirely disappeared. At this time he complained of some numbness in the right foot. On the twelfth day he complained of pain in the left buttock and down the flexor surface of the left thigh. There was no pain on the right side. Movements in the left hip and knee joints were slightly weaker than in the right. On the left, plantar flexion of the ankle joint was of almost normal strength, and dorsal flexion and pronation, though still weak, were normal in extent. On both sides movement of the toes was normal and the patellar reflexes were positive and equal, but the achilles reflex was absent. There were no sensory disturbances. At no time was there any motor weakness or anesthesia or any lack of control of the bladder and the anal sphincters, though there was some frequency of urination. The dysuria complained of before operation had entirely disappeared.

The patient was discharged on the twelfth postoperative day, with all his symptoms markedly improved and with every indication that recovery would be complete. In spite of repeated requests he has failed to return for a follow-up study.

The excised specimen was reported microscopically as a portion of fibrous cartilage with calcification.

COMMENT

In spite of the rather extensive literature which has arisen about protruded intervertebral disk, several phases of the condition are still far from clear. There is still not complete agreement, for one thing, as to exactly what the pathologic process is. Schmorl and Junghans,[6] who described the protrusion as a "nodule," and Andrae,[7] who spoke of it as *Knorpelknötchen,* stated the belief that the pathologic change is primarily prolapse of the disk secondary to a tear in the annulus fibrosus.

6. Schmorl, G., and Junghans, H.: Die gesunde und kranke Wirbelsäule im Röntgenbild, Leipzig, Georg Thieme, 1932.

7. Andrae, R.: Ueber Knorpelknötchen am hinteren Ende der Wirbelbandscheiben im Bereich des Spinalkanals, Beitr. z. path. Anat. u. z. allg. Path. **82**:464, 1929.

Slaughter [8] expressed the same opinion. Alpers, Grant and Yaskin [9] pointed out that in their cases the herniated mass consisted microscopically of fibrocartilage, which is histologically very different from the nucleus pulposus. Mixter and Ayer [10] found both nucleus pulposus and annulus fibrosus in their specimens.

There is also some discussion as to whether the protruding mass should not be considered a neoplasm. The data in 1 of the cases reported by Alpers, Grant and Yaskin [9] and in another, reported by Bucy,[11] furnish histologic evidence to this effect. Elsberg [12] took an intermediate position, suggesting that the protruding mass is not a true neoplasm but a form of local hyperplasia of the cartilage, which can be described as ecchondrosis. The findings in our own case suggest the same interpretation.

The case which we have reported is like most other cases in that the etiologic factor was traumatic. On the other hand, Stookey,[13] Elsberg [12] and Bucy,[11] in most of whose cases localization of the pathologic process was in the cervical portion of the spine, stated the opinion that trauma is a rare cause and advocated a neoplastic hypothesis. Mixter and Ayer,[10] Love and Walsh,[5] Hampton and Robinson [14] and Simonds,[15] in most of whose cases localization was in the lumbar portion of the spine, usually between the fourth and the fifth lumbar vertebra, concluded that trauma is a very important cause. Love and Walsh,[5] in discussing this point, noted that the condition in the greatest number of cases occurs in the area of the greatest convexities of the spine, which in heavy lifting or pushing bear the greatest mechanical strain. These

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8. Slaughter, R. F.: Herniation or Rupture of Intervertebral Disc: Report of Two Cases, South. M. J. **30**:803, 1937.

9. Alpers, B. J.; Grant, F. C., and Yaskin, J. C.: Chondroma of the Intervertebral Disks, Ann. Surg. **97**:10, 1933.

10. Mixter, W. J., and Ayer, J. B.: Herniation or Rupture of the Intervertebral Disk into Spinal Canal, New England J. Med. **213**:385, 1935.

11. Bucy, P. C.: Chondroma of Intervertebral Disk, J. A. M. A. **94**:1552 (May 17) 1930.

12. Elsberg, C. A.: Extradural Spinal Tumors: Primary, Secondary, Metastatic, Surg., Gynec. & Obst. **46**:1, 1928; The Extradural Ventral Chondromas (Ecchondroses): Their Favorite Sites, Spinal Cord and Root Symptoms They Produce, and Their Surgical Treatment, Bull. Neurol. Inst. New York **1**:350, 1931.

13. Stookey, B.: Compression of the Spinal Cord Due to Ventral Extradural Cervical Chondromas: Diagnosis and Surgical Treatment, Arch. Neurol. & Psychiat. **20**:275 (Aug.) 1928.

14. Hampton, A. O., and Robinson, J. M.: The Roentgenographic Demonstration of Rupture of Intervertebral Disk into the Spinal Canal After the Injection of Lipiodol, with Special Reference to Unilateral Lumbar Lesions Accompanied by Low Back Pain with "Sciatic" Radiation, Am. J. Roentgenol. **36**:782, 1936.

15. Simonds, F. L.: Low Back Pain Due to Herniation or Rupture of Intervertebral Disc into Spinal Canal, Nebraska M. J. **22**:456, 1937.

facts obviously fit better with the conception of herniation than with that of neoplasm. The condition in Dandy's [16] 2 cases, in which loose cartilage instead of herniated tissue was found, was probably due to a traumatic mechanism.

The calcification observed in our specimen fits into the picture of trauma, for calcification in traumatized cartilage is not altogether rare. Schmorl and Junghans [6] made the statement that posterior ruptures of the nucleus pulposus may be associated with calcification, but Hampton and Robinson,[14] who observed calcification in only 1 of 39 cases studied, concluded that this process was not true calcification but a fragment of fractured vertebra. In view of the differing reports in the literature it seems reasonable to question whether the condition is similar either etiologically or pathologically in all cases.

As all reports have pointed out, the clinical symptoms of protrusion of an intervertebral disk are most often those of persistent lumbago or sciatica which makes its appearance immediately after a strain or injury and which does not respond to any of the usual methods of treatment. In some cases symptoms are delayed, and in others, as in 29 of the 100 reported by Love and Walsh,[5] no history of trauma can be obtained. Echols [17] recently called attention to the importance of suspecting this condition in cases of supposed sciatica which does not respond to the usual measures and has outlined the mechanism by which the pain is produced.

Visualization of the spinal canal by injection of iodized poppyseed oil should always be employed. It usually shows a ventral filling defect and only rarely a complete block, as in our case and in the cases reported by Slaughter,[8] Capener,[18] Simonds,[15] Mixter and Ayer [10] and Hampton and Robinson.[14]

In the cases reported by Flothow,[19] Mixter and Ayer [10] and Hampton and Robinson,[14] as well as in our own, there was evidence of a lesion of the cauda equina with the pain syndrome, manifested by loss of the achilles reflexes, hyperesthesia of the sacral segments, sphincteric disturbances and more or less marked motor weakness. That the pain is due to compression by the protruding disk of the nerve root as it emerges from the dural canal is an entirely satisfactory explanation in those cases in which lumbago or sciatic pain is the only clinical symptom. It is not, however, a satisfactory explanation in cases in which the

16. Dandy, cited in footnote 4.

17. Echols, D. H.: Ruptured Intervertebral Disk: A Cause of Sciatic Pain, New Orleans M. & S. J. **91**:243, 1938.

18. Capener, N.: Intractable Sciatica Due to Prolapsed Intervertebral Disk: Treated by Laminectomy, Proc. Roy. Soc. Med. **30**:1262, 1937.

19. Flothow, P. G.: Nucleus Pulposus and Hypertrophy of the Ligamentum Flavum, Northwest Med. **37**:14, 1938.

protruding cartilage is very small and the neurologic lesion is extensive. This disproportion existed in our case, in which the size of the protrusion was even less than the 0.75 to 1 cm. mentioned by Naffziger, Inman and Saunders [20] and others. In such severe involvement there is evidently compression of the entire dural canal, which cannot be accounted for merely by the pressure of the protruding cartilage.

In our personal case and in such similar ones as those reported by Hampton and Robinson [14] and by Slaughter,[8] a more complex pathogenic mechanism is evidently responsible. In our opinion this mechanism is inflammatory. The unusually high number of cells (200 per cubic millimeter) in the spinal fluid in our case seems to point definitely to an inflammatory process, which, we believe, is local circumscribed arachnoiditis provoked by mechanical irritation from the protruding disk. A consideration of the operative findings supports this point of view. After the subarachnoidal space was opened, spinal fluid gushed out, and pulsation soon became apparent for the first time. There were no macroscopic local changes in the meninges, and our idea is that with the dura an arachnoiditic cyst was opened, which contained spinal fluid, increased by some exudate, under considerable pressure. Such a cyst could easily account both for the blockage of the canal which was noted in successive roentgenograms and for the compression of the cord which caused the severe clinical symptoms. The very low pressure found at spinal puncture before operation is accounted for by the fact that the puncture was made between the third and the fourth lumbar vertebra, that is, below the arachnoiditic cyst. The high globulin content of the spinal fluid is also evidence of the chemical changes which are to be expected in association with compression.

It has long been known that circumscribed meningitis, of whatever origin, may produce all the symptoms of a tumor of the spinal cord. Thorburn,[21] in 1918, said: "The writer has operated upon at least one case in which careful exploration for a tumor of the cauda equina, of which the symptoms were regarded as unequivocal, revealed no growth, but in which the theca presented distinct thickening and contained much fluid, while complete recovery ensued." In a case in which a diagnosis of protrusion of the intervertebral disk had been made, Peet and Echols [22]

20. Naffziger, H. C.; Inman, V., and Saunders, J. B.: Lesions of Intervertebral Disc and Ligamenta Flava: Clinical and Anatomical Studies, Surg., Gynec. & Obst. **66**:288, 1938.

21. Thorburn, W.: Operations upon the Spinal Cord and Canal, in Burghard, F. F., and Kanavel, A. B.: Oxford Surgery, New York, Oxford University Press, 1918, sect. 5, pt. 2, p. 416.

22. Peet, M. M., and Echols, D. H.: Herniation of the Nucleus Pulposus: A Cause of Compression of the Spinal Cord, Arch. Neurol. & Psychiat. **32**:924 (Nov.) 1934.

found xanthochromia, 38 lymphocytes per cubic millimeter and a colloidal gold curve in which the maximum precipitation was shifted to the right. Thickening of the arachnoidea was established. In Slaughter's [8] case there were 33 cells per cubic millimeter of spinal fluid and a midzone rise in the colloidal gold curve. In Capener's [18] case the dura was opened and an apparent circumferential constriction found, but the projecting portion of the disk was not removed.

In view of these facts, the question arises whether cases of protruded intervertebral disk should not be divided into two groups:

1. Cases of lumbar or sacral radiculitis caused by pressure of a protruding intervertebral disk.

2. Cases in which the symptoms are those of a lesion of the cauda equina and are due to circumscribed meningitis which has been provoked by the mechanical irritation of a protruding intervertebral disk.

SUMMARY

A case is recorded in which protrusion of the fourth intervertebral disk, with consecutive circumscribed spinal meningitis, gave rise to symptoms simulating those of a tumor of the cauda equina. Incision of the meningitic cyst and excision of the small protruding disk initiated recovery.

This case and a few similar cases recorded in the literature suggest that a distinction is justified between (*a*) cases of lumbar or sciatic radiculitis caused by the pressure of a protruding intervertebral disk and (*b*) cases of compression of the cauda equina by a meningitic cyst which has developed from the mechanical irritation produced by the protrusion of an intervertebral disk.

STUDIES IN CROSS CIRCULATION

HARRIS B. SHUMACKER JR., M.D.

AUSTIN LAMONT, M.D.

AND

WILLIAM METCALF, M.D.

BALTIMORE

In 1931 Firor [1] described a method for crossing the circulations of dogs by means of an end to end anastomosis (according to Carrel's technic) of the carotid artery of one dog and the jugular vein of another, and vice versa.[2] No anticoagulant was required. Firor found this a reliable method for providing adequate mixing of the blood and made certain physiologic observations during the procedure. The methods which had been previously used were reviewed,[3] and attention was called to the fields of investigation in which these procedures had been employed. Recent studies involving the use of cross circulation [4] have suggested the need for additional information concerning the accompanying physiologic changes, especially the alterations in plasma and blood volume, the changes in blood pressure and the influence of such changes on the blood volumes, and the rapidity and completeness of mixing of the blood.

MATERIAL AND METHOD

We have employed Firor's technic in our experiments and have found it reliable, relatively simple and not time consuming. The time required for operation was fifty to sixty minutes. Only one change has been instituted: In experiments of short duration it has proved easier to place the animals on the table so that their heads face in opposite directions. The wound may be left open and merely covered with a pledget of cotton moistened with warm physiologic solution of sodium chloride, a method which permits routine inspection at frequent intervals to make

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From the Surgical Hunterian Laboratory, Johns Hopkins University School of Medicine.

1. Firor, W. M.: Experiments in Cross Circulation, Am. J. Physiol. **96**:146-152, 1931.

2. In 1925 Ivy, Lim and McCarthy (Am. J. Physiol. **74**:616-638, 1925) utilized actual anastomosis by suture in producing cross circulation. These authors, however, did carotid to carotid and carotid to carotid and also carotid to carotid and jugular to jugular anastomoses.

3. Firor, W. M.: A Review of Cross Circulation Experiments, New England J. Med. **204**:157-159, 1931.

4. Firor, W. M.; Lamont, A., and Shumacker, H. B., Jr.: Studies on the Cause of Death in Tetanus, Ann. Surg., to be published.

sure of the proper functioning of the anastomoses.[5] The operations were done with the dogs under pentobarbital sodium anesthesia. In the study reported here normal healthy mongrel dogs were used except in experiments concerned with changes in temperature and the effect of muscular exercise on the blood sugar levels. In the latter instances cross circulation was produced between a normal dog and a dog having almost constant clonic convulsions of the hindlimbs consequent to the injection of tetanus toxin into the lumbar portion of the spinal cord.[4]

Samples of blood were collected in bottles containing dried potassium and ammonium oxalate.[6] For hematocrit determinations the Wintrobe hematocrit tubes were used. Determinations of the values for blood sugar were done according to the Folin-Wu technic. The values for plasma proteins were determined by the falling drop method with the LaMotte densimeter. Mean arterial blood pressures were obtained by means of a cannula in the carotid artery connected with a mercury manometer, a small bulb filled with sodium citrate solution near the cannula being employed to prevent clotting.

The plasma volume of each dog was determined immediately after completion of the anastomoses and before cross circulation was begun (with the rubber-shod artery clamps still in place) and again immediately after the cross circulation was ended. The photoelectric microcolorimetric technic with the azo blue dye T 1824 [7] was used. Since the original plasma volumes and concentrations of proteins in the plasma were known, the plasma volume for each dog before the anastomoses were opened and the combined volume for both dogs during the period of cross circulation could be estimated from the plasma protein concentrations, the amount of plasma which had been withdrawn in blood sampling being taken into consideration. This method is accurate provided there has been no loss of proteins other than that due to bleeding, and there is good evidence that this is true and the method is valid. The question of loss of proteins could be checked accurately in those experiments in which no loss of blood was sustained when the anastomoses were opened at the beginning of the cross circulation. In these instances the values for total protein at the beginning of the experiment and at the end, calculated from the values for plasma volume obtained by the dye method and the protein concentration, checked within 2.5 per cent. In the other experiments in which it was necessary to include in the calculations an estimate of the amount of blood lost on opening the anastomoses the values for total protein at the beginning and at the end of the experiments generally checked within 1.5 per cent, and the discrepancy was never greater than 5 per cent.

RESULTS

Blood Pressure.—In table 1 are recorded changes in blood pressure during cross circulation. It is apparent that there is, in general, a drop in pressure in both dogs shortly after cross circulation is begun. The drop is generally precipitous and considerable. After this initial fall there is a tendency for the pressure to rise toward its former level.

5. In longer experiments the animals should be placed head to head, the wound closed and the necks and forelegs strapped together with adhesive tape. The functioning of the anastomoses can be ascertained by detection of a bruit.

6. One and three-tenths grams of ammonium oxalate and 0.7 Gm. of potassium oxalate in 100 cc., 0.1 cc. for each each cubic centimeter of blood (Wintrobe).

7. Gibson, J. G., Jr., and Evelyn, K. A.: Clinical Studies of the Blood Volume: IV. Adaptation of the Method to the Photoelectric Micro-Colorimeter, J. Clin. Investigation **17**:153-158, 1938.

TABLE 1.—*Changes in Blood Pressure During Cross Circulation*

Experiment No.	Dog	Mean Arterial Blood Pressure, Mm. of Hg													
		Original	Before Anastomosis Was Opened	2 Minutes After	5 Minutes After	10 Minutes After	30 Minutes After	45 Minutes After	60 Minutes After	80 Minutes After	100 Minutes After	120 Minutes After	135 Minutes After	200 Minutes After	After Anastomosis Was Closed
1	A	140	149	62	73	84	100	110	118	128	134	137	143	141	150 to 145
	B	144	60	98	96	80	84	96	101	104	123	122	124	124	125 to 130
2	A	158	164	145	60	60	75	75	75	70	68	60	...	...	90 to 104
	B	148	60	145	160	160	118	135	142	145	144	150	...	...	155 to 145
2	A	160	145	...	115	100	110	90	98	115	125	126	...	...	125 to 108
	B	110	130	...	105	105	100	72	62	70	95	95	...	...	100 to 100
4	A	178	165	95	20	65	72	64	60	72	82	85	...	...	95 to 118
	B	150	80	132	60	72	98	102	120	160	170	170	...	...	144 to 110
5	A	132	130	60	24	50	104	94	70	62	100	110	...	...	115 to 136
	B	140	78	60	50	62	84	85	76	74	75	90	...	...	95 to 100
8	A	164	125	...	140	124	79	122	130	132	130	134	...	...	122 to 72
	B	168	162	...	154	110	83	112	118	108	106	94	...	...	105 to 118
10	A	162	152	...	150	128	144	142	136	124	120	112	116	...	122 to 108
	B	180	146	...	38	100	132	132	132	148	160	180	178	...	178 to 164
11	A	190	172	122	...	100	90	130	140	148	118	136	...	...	150 to 105
	B	165	156	143	...	116	106	150	158	158	156	155	...	...	168 to 156

After the cross circulation is ended the pressures usually rise. There is no correlation between the original blood pressure and that observed during the cross circulation.

Plasma and Total Blood Volume.—We have tabulated the essential data in table 2 and have charted 3 illustrative experiments (charts 1, 2 and 3). Our chief concern has been the question of blood shift from one animal to the other during the cross circulation. The results in

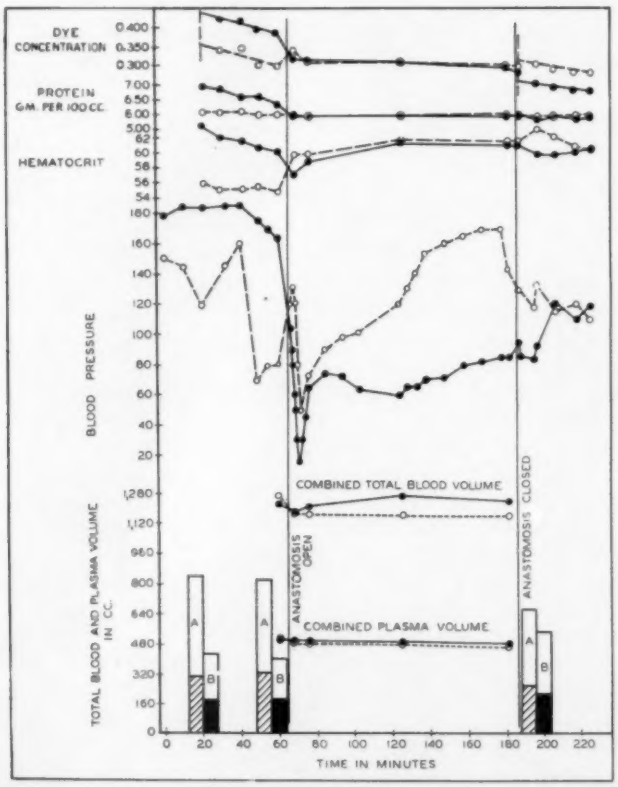

Chart 1 (experiment 4).—Loss of blood from dog A (the larger dog) to dog B (the smaller dog). The difference in the blood pressures during cross circulation is to be noted. In this, as well as in charts 2 and 3, the promptness and adequacy of the mixing of dye, proteins and red cells is illustrated; also the increase in the total blood volume during cross circulation. In charts 1, 2 and 3 the values for dog A are charted as unbroken lines and solid circles and those for dog B as broken lines and open circles. Likewise, in all three charts the solid lines accompanying the words "combined total blood volume" and "combined plasma volume" represent the actual calculated values, and the dotted lines represent the estimated values obtained by deducting from the original values the amounts withdrawn. The cross-hatched and solid portions of the columns represent the plasma volume; the total height of the columns, the total blood volume. The optical density is charted as dye concentration.

table 2 are expressed in the number of cubic centimeters of difference between the calculated and the actual volume after the cross circulation.

The final values for blood and plasma volume cannot be safely estimated by simply deducting the volume withdrawn for examination and adding the volume of dye solution introduced during the procedure, for there are increases and decreases in blood and plasma volume out of proportion to the amount of fluid withdrawn or added. For example, although 20 cc. of blood was drawn and from 13 to 20 cc. of fluid added during the forty minutes between the original

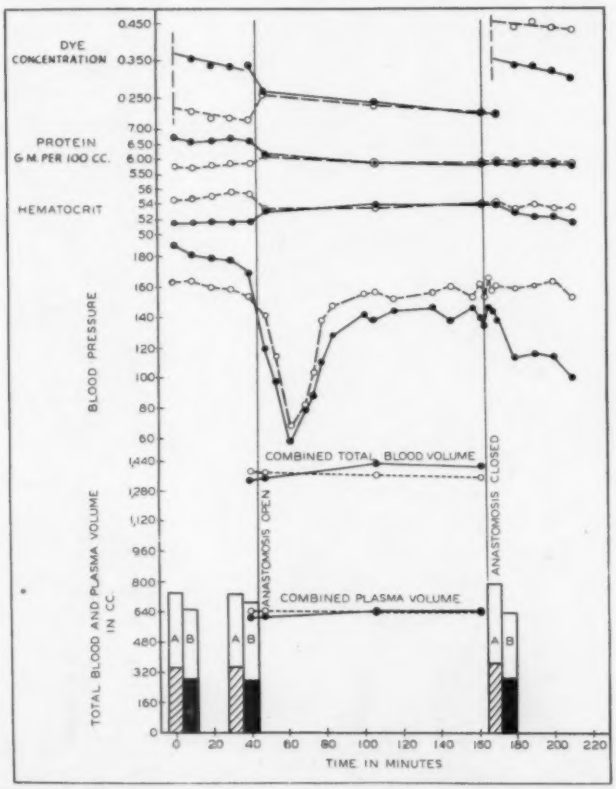

Chart 2 (experiment 11).—Chart showing no relative change in total blood and plasma volume during cross circulation in two dogs of nearly equal size. The blood pressures of the dogs do not differ greatly during cross circulation.

determinations of volume and those recorded just before the anastomoses were opened, there were changes in plasma volume as great as + 46 and — 26 cc. and in total blood volume as great as + 133 and — 66 cc. Furthermore, the difference between the actual calculated combined plasma volumes toward the end of cross circulation and the values estimated by subtraction of the removed fluids from the sum of the initial values for plasma volume varied from + 44 to — 20 cc., while the difference between the actual calculated and the estimataed total values for blood volume varied from + 203 to — 25 cc. Consequently, in calculating the final values which might be expected if no shift had taken place, we have assumed that

the combined plasma and total blood volumes just before the cross circulation was ended would be distributed between the two dogs in the same proportion that existed just before cross circulation was begun. Though not entirely accurate, since further changes may take place during a few minutes before reinjection of the dye, this is a reasonably good method of calculating what the final values would be if there were no loss of blood from 1 dog to the other.

The preceding discussion, furthermore, makes evident two other points. The plasma volume varies decidedly less than does the total red

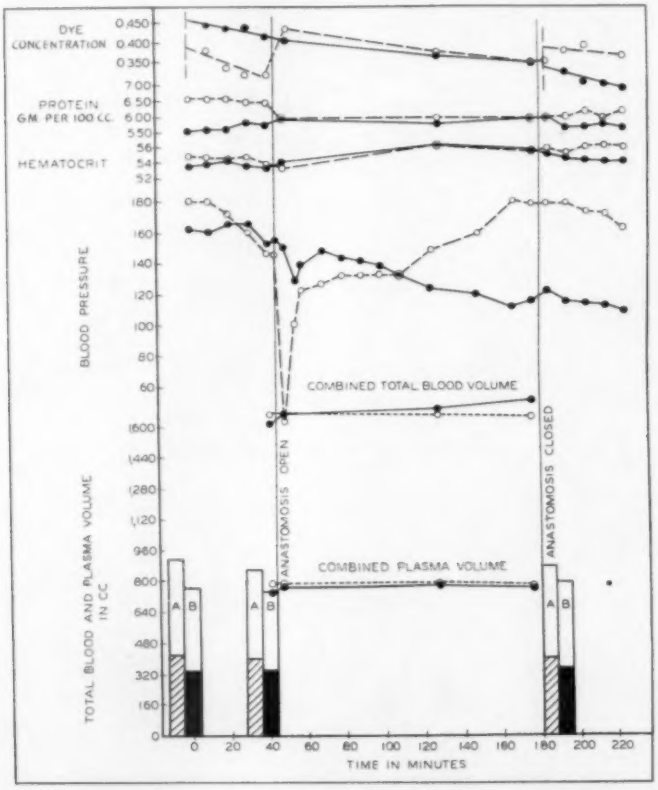

Chart 3 (experiment 10).—Chart illustrating the fact that blood pressures may differ considerably without causing a loss of blood from one animal to the other.

cell volume and consequently varies less than the total blood volume; hence determinations of the plasma volume are more reliable than determinations of the total blood volume as far as estimation of blood shift is concerned. Only fairly great changes can be considered significant evidence of shift of blood from one animal to the other, because the values vary widely even when there has been no stimulus other than the withdrawal or addition of a few cubic centimeters of fluid.

TABLE 2.—*Studies of the Blood and Plasma Volume During Cross Circulation*

Experiment No.	Dog	Total Blood Volume, Cc.				Plasma Volume, Cc.				Duration of Cross Circulation, Hours	Weight of Dog, Kg.	Blood Pressure During Cross Circulation
		Original	Just Before Anastomosis Was Opened	Final	Difference Between Calculated and Actual Final Volumes	Original	Just Before Anastomosis Was Opened	Final	Difference Between Calculated and Actual Final Volumes			
1	A	503	475	426	— 8	253	250	221	— 9		5.20	62; 118; 137; 141
	B	510	497	432	— 22	242	241	216	+ 2	3.5	4.55	98; 101; 122; 124
2	A	1,134	1,080	813	—218	525	499	364	—130		10.40	60; 75; 60
	B	492	524	636	+ 87	225	221	285	+ 67	2	4.90	160; 142; 150
3	A	785	918	707	— 68	380	426	331	— 19		9.00	115; 98; 126
	B	564	561	476	+ 3	285	275	227	— 22	2	5.50	103; 62; 95
4	A	841	819	660	—165	307	326	256	— 50		6.80	20; 60; 82
	B	432	407	553	+128	190	183	213	+ 41	2	4.90	60; 120; 170
5	A	615	626	554	— 90	310	313	278	— 37		7.60	24; 104; 62; 100
	B	461	430	488	+ 45	240	232	245	+ 11	2	5.20	50; 84; 74; 75
8	A	494	480	500	— 14	209	216	214	+ 3		7.73	140; 130; 130
	B	522	525	...	.....	258	248	...	.....	2	7.72	154; 118; 106
10	A	915	855	876	— 45	425	400	401	— 9		10.90	150; 142; 120
	B	768	747	749	— 9	348	345	351	— 3	2.25	8.40	88; 132; 160
11	A	750	738	798	+ 15	359	354	376	+ 11		7.10	100; 140; 118
	B	654	626	639	— 13	294	278	294	— 5	2	6.20	116; 158; 156

In the 8 experiments which we carried out a considerable shift of blood occurred in 1 (experiment 2) and a fairly definite shift in another (experiment 4). In both instances there was a pronounced difference between the original blood and plasma volumes for the two dogs, and in both the larger dog lost blood to the smaller. In both experiments there was a great difference between the blood pressures of the two dogs during the period of cross circulation, and in both the loss of blood was suffered by the dog with the lower pressure. The details of experiment 4 may be seen in chart 1. In a third experiment (experiment 3) in which there was a wide difference between the original blood and plasma volumes of the two dogs there was no loss of blood from one animal to the other. A slight shift did occur in experiment 5. In this experiment there was a moderate difference in the original blood and plasma volumes of the two animals and very little difference between the blood pressures, and again the loss of blood was from the larger dog to the smaller. In none of these experiments was the loss of blood sufficient to cause the death of the animal. In the remaining experiments, in which the original blood and plasma volumes of the two dogs varied less, there was no apparent loss of blood from one animal to the other. Chart 2 represents experiment 11, in which the blood pressures varied little; chart 3 represents experiment 10, in which during the last hour of cross circulation there was a significant difference between the blood pressures of the two dogs.

In every instance except 1 (experiment 1) there was an apparent increase in the combined total blood volumes during cross circulation. This was largely due to an increase in the total red cell volume, as there was either no increase or very little increase in the plasma volume during this period. These changes may be seen in charts 1, 2 and 3.

Mixing of Formed and Chemical Elements of the Blood.—In table 3 are recorded changes in the volume of packed red cells during cross circulation, and in table 4, changes in the level of plasma proteins. It is evident that the values for the two dogs tended to become approximately equal within a few minutes after cross circulation was begun and to remain approximately equal during the experiment. The same holds true for the concentration of the azo blue dye, as may be seen in the 3 experiments charted.

The question arose whether if any chemical substance were utilized by one animal more rapidly than by the other or were supplied to one animal in greater quantity than to the other the values for this substance would be unequal in the 2 animals. In order to test this question the following experiments were done. First, to one of a pair of normal dogs between which adequate cross circulation had been established a slow intravenous drip of 50 per cent dextrose solution was given over

TABLE 3.—*Hematocrit Studies During Cross Circulation*

Experiment No.	Dog	Volume per Cent of Packed Red Cells													
		Originally	Just Before Anastomosis Was Opened	2½ Minutes After	3 Minutes After	10 Minutes After	15 Minutes After	20 Minutes After	25 Minutes After	45 Minutes After	60 Minutes After	120 Minutes After	180 Minutes After	450 Minutes After	After Anastomosis Was Closed
1	A	49.7	45.5	....	....	....	....	....	....	....	50.0	51.2	49.5	....	48.2
	B	52.5	51.5	....	....	....	....	....	....	....	49.7	51.0	50.2	....	48.0
2	A	53.7	53.8	....	....	55.0	54.5	53.5	54.0	....	....	56.0	....	....	55.8
	B	54.3	57.6	....	....	55.8	54.8	55.0	53.8	....	....	57.0	....	....	55.2
3	A	51.6	53.6	....	....	51.2	51.0	....	....	51.3	....	52.1	....	....	53.2
	B	49.5	51.0	....	....	51.3	51.2	....	....	52.0	....	51.9	....	....	52.4
4	A	63.5	60.2	57.1	....	58.9	....	....	....	....	61.4	61.2	....	....	61.2
	B	56.0	54.9	59.8	....	60.0	....	....	....	....	61.9	61.5	....	....	61.4
5	A	51.2	50.1	....	48.2	46.8	....	....	....	49.6	....	49.6	....	....	49.8
	B	47.9	46.0	....	49.0	48.1	....	....	....	49.8	....	49.9	....	....	49.8
7	A	55.0	....	....	53.4	....	....	....	....	....	55.0	52.6	....	....	....
	B	50.0	....	....	53.2	....	....	....	....	....	55.0	53.2	....	....	....
8	A	57.7	55.0	....	....	54.5	....	....	....	....	54.0	58.2	....	....	58.0
	B	50.6	52.8	....	....	54.5	....	....	....	....	54.5	58.0	....	....	58.0
9	A	54.5	54.2	....	54.6	....	....	....	....	....	59.4	58.0	....	....	64.5
	B	60.0	60.0	....	54.4	....	....	....	....	....	59.2	58.3	....	....	63.5
10	A	53.6	53.2	....	54.0	....	....	....	....	....	56.2	55.8	....	....	55.0
	B	54.8	53.8	....	53.2	....	....	....	....	....	56.2	55.6	....	....	55.8
11	A	51.8	52.0	53.4	....	....	....	....	....	....	54.3	54.2	....	....	54.4
	B	46.8	43.0	53.6	....	....	....	....	....	....	54.0	54.4	....	....	54.8
15	A	49.0	....	....	....	....	....	....	....	....	....	....	....	52.0	....
	B	42.0	....	....	....	....	....	....	....	....	....	....	....	51.0	....

TABLE 4.—*Studies of the Plasma Protein During Cross Circulation*

Experiment No.	Dog	Plasma Protein, Gm. per 100 Cc.												
		Originally	Just Before Anastomosis Was Opened	2.5 Minutes After	5 Minutes After	10 Minutes After	15 Minutes After	20 Minutes After	25 Minutes After	45 Minutes After	60 Minutes After	120 Minutes After	180 Minutes After	After Anastomosis Was Closed
1	A	5.00	4.65	....	....	....	....	....	....	....	4.40	4.45	4.45	4.65
	B	4.50	4.30	....	....	....	....	....	....	....	4.40	4.50	4.75	4.75
2	A	6.86	7.10	....	....	6.65	6.55	6.73	6.55	....	....	6.39	....	6.73
	B	6.86	6.69	....	....	6.94	6.94	6.76	6.86	....	....	6.43	....	7.15
3	A	6.58	5.72	....	....	5.65	5.51	....	....	5.51	....	5.51	....	5.51
	B	5.51	5.51	....	....	5.51	5.39	....	....	5.17	....	5.39	....	5.28
4	A	6.96	6.38	5.97	....	5.97	....	....	....	....	5.97	5.97	....	6.04
	B	6.10	6.04	6.04	....	5.97	....	....	....	....	5.97	6.04	....	5.97
5	A	5.94	5.70	....	5.66	5.22	....	....	....	4.95	....	4.98	....	5.22
	B	5.64	5.60	....	5.25	5.29	....	....	....	5.22	....	4.95	....	4.95
8	A	6.10	5.65	....	....	5.70	....	....	....	....	5.45	5.76	....	6.00
	B	6.27	6.28	....	....	5.94	....	....	....	....	5.70	5.90	....	5.94
9	A	6.50	6.46	....	6.00	....	....	....	....	....	5.78	5.63	....	5.65
	B	6.10	6.08	....	5.79	....	....	....	....	....	5.75	5.66	....	5.67
10	A	5.52	5.80	....	5.96	....	....	....	....	....	5.72	5.90	....	5.90
	B	6.58	6.48	....	5.96	....	....	....	....	....	5.90	5.90	....	5.90
11	A	6.75	6.75	6.24	....	....	....	....	....	....	5.95	5.95	....	5.98
	B	5.76	5.90	6.22	....	....	....	....	....	....	5.95	5.95	....	6.02

a period of an hour and three quarters at the rate of about 1.7 cc. per minute. The result is shown in chart 4. The animal receiving the infusion maintained a higher blood sugar level than did the other, the difference varying from 10 to 91 mg. per hundred cubic centimeters. In other experiments, in which cross circulation was established between a normal dog and a dog in active convulsions from induced tetanus (table 5), the blood sugar level of the dog undergoing violent exercise consistently remained much lower than that of the normal dog.

Pulse, Respiration and Temperature.—The differences which others have noted [1] in the pulse rates and respiratory rates of two animals during cross circulation were confirmed by our studies. Others [1] also

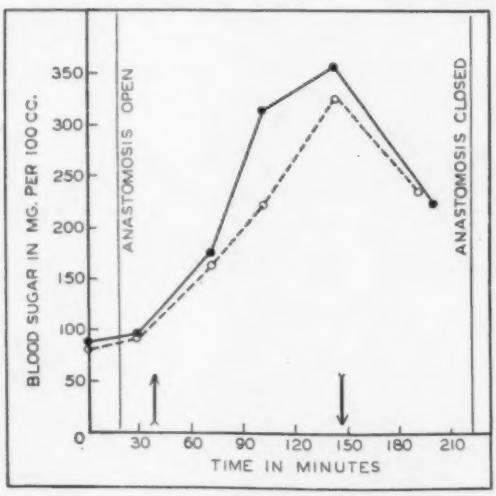

Chart 4 (experiment 6).—Chart showing values for blood sugar in 2 dogs during cross circulation, one of which is given an intravenous drip of dextrose solution. The arrows indicate the points at which the infusion in dog A (unbroken line) was begun and ended.

have found that the temperatures of animals during cross circulation may be different. We have made no studies of the temperature during cross circulation with normal animals, but we have made observations in about 40 experiments in which cross circulation has been established between a normal dog and a dog with tetanus. In these experiments (chart 5) the temperature of the normal dog rises with that of the dog with tetanus though it remains usually a degree or so lower. The temperature of the dog with tetanus is not proportionately reduced but is, on the other hand, just about what it would be if cross circulation had not been carried out.

COMMENT

Firor's technic for cross circulation is a reliable method for providing prompt and adequate mixing of the bloods of two animals. It is relatively simple and requires no elaborate equipment. The volume of packed red cells, the plasma proteins and the concentration of the dye become approximately equal in the two dogs within a few minutes after cross circulation is begun. Firor [1] has likewise shown that the values for chlorides, phosphates and sugar are equal during cross circulation. If one element of the blood, for example, sugar, is supplied continuously in greater amount to or is utilized more rapidly by one dog than by the other, the concentrations will not be equal. The

TABLE 5.—*Effect of the Convulsions of Tetanus on Blood Sugar During Cross Circulation* *

Experiment No.	Subject	Blood Sugar, Mg./100 Cc. Before Cross Circulation	2 Hours After	4 Hours After	5 Hours After	21 Hours After	Therapy
12	Dog with tetanus	53	..	65	..	..	None
	Normal dog	95	..	96	..	..	None
13	Dog with tetanus	43	47	..	45	..	None
	Normal dog	90	89	..	102	..	None
14	Dog with tetanus	48	..	..	..	48	85 Gm. dextrose by vein from 1 to 15 hours after cross circulation was begun
	Normal dog	88	..	..	..	98	25 Gm. dextrose by vein 4 hours after cross circulation was begun; 280 cc. saturated dextrose solution by mouth from 1 to 2 hours before last blood sugar determination

* One dog in each experiment had severe convulsive movements of the hindlimbs consequent to the injection of tetanus toxin into the lumbar portion of the spinal cord.

temperature of a normal dog rises when cross circulation is established between it and a dog with an experimentally induced fever (tetanus). Pulse and respiration do not follow the same rate in both animals. The blood pressures of the two animals may differ widely. There is a tendency for an abrupt and relatively great fall in pressure to take place shortly after cross circulation is begun and for a gradual rise toward the normal level to occur thereafter. The drop is probably due to the sudden decrease in the peripheral resistance associated with opening of the arteriovenous fistula. The blood pressures during cross circulation do not bear any constant relation to the preoperative pressures. There is generally an absolute increase in total blood volme during cross circulation, effected almost entirely through an increase in the total circulating red cell volume.

With dogs of roughly equal weight and consequently with approximately equal blood and plasma volume there is apparently no danger of net loss of blood from one animal to the other, even though there may be moderately great differences in the mean arterial blood pressures during the procedure. When the original blood and plasma volumes of the two dogs are very different there may occur a net loss of blood from the larger dog to the smaller, though this does not invariably take place. This can occur when the larger animal has a blood pressure much lower than that of the smaller. The lower arterial blood pressures in these experiments may be the result of loss of blood rather than one

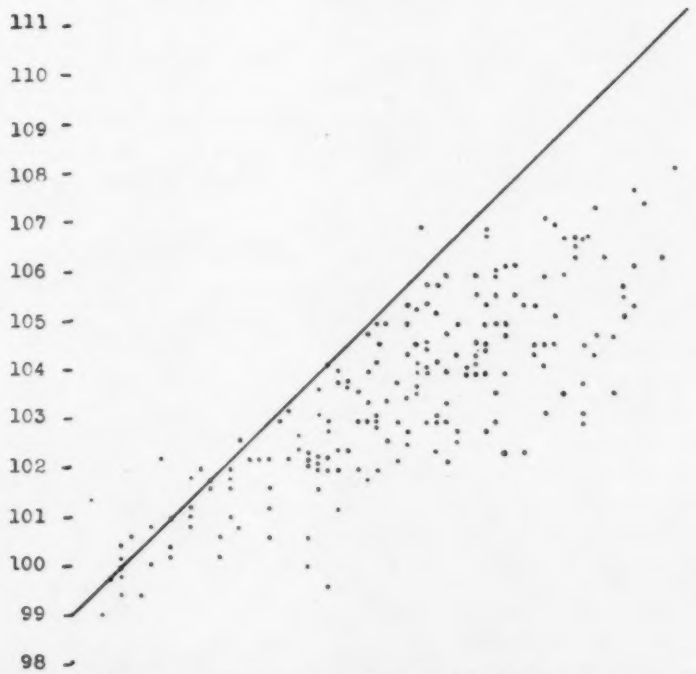

Chart 5.—Distribution curve of temperatures of normal dogs compared with corresponding temperatures of dogs with tetanus with which they were paired for cross circulation. The temperatures of the normal dogs are plotted as dots in a vertical line crossing the corresponding temperatures of the dogs with tetanus, represented by the diagonal line.

of its causes. In other experiments (chart 3) significant differences in blood pressure were not associated with loss of blood from one animal to the other. In no instance during cross circulation did an animal with high blood pressure lose blood to one with a much lower pressure. These observations are rather surprising, since volume flow depends in part on the pressure gradient. That the cross section of the arteries anastomosed was likewise not the chief factor in the blood shift in the

few instances in which it occurred is suggested by the fact that there was considerable difference in the size of the carotid arteries in a number of experiments in which no loss of blood took place.

SUMMARY

During cross circulation of dogs of approximately equal size no net loss of blood from one dog to the other was observed. In a few instances in which dogs with very different blood volumes were used for cross circulation a net loss of blood from the larger dog to the smaller took place. The arterial blood pressure is not the primary factor in the shift of blood. The loss of blood may be sustained by the animal with the lower pressure.

During cross circulation there is almost invariably an absolute increase in the combined total blood volume of the two animals, effected almost entirely by an increase in the total circulating red cell volume.

There is usually a definite fall in mean arterial blood pressure when the cross circulation is begun, after which there is a rise toward the normal level.

The pulse and respiratory rates of dogs during cross circulation may be different. The temperature of a normal dog rises when cross circulation is established between it and a dog with an experimentally induced fever (tetanus).

There is approximately complete mixing of the formed and chemical elements of the blood within two and one-half minutes after cross circulation is begun. If during cross circulation one chemical element (e. g., dextrose) is constantly supplied to the blood stream of one animal in greater quantity than to that of the other or if it is utilized by one dog more rapidly than by the other, the concentration will not be equal in the two animals.

INTRA-ABDOMINAL HERNIA

REPORT OF A CASE AND REVIEW OF THE LITERATURE

G. H. HANSMANN, M.D.
AND
S. A. MORTON, M.D.
MILWAUKEE

The literature on intra-abdominal hernia is composed for the most part of individual case reports, studies of limited groups of cases and reviews of special types of hernia. Moynihan and Dobson described various peritoneal fossae and made a fairly complete review of the cases of intra-abdominal hernia reported up to 1906. Short reviewed the cases reported between 1906 and 1915. In 1925 Short also reviewed cases in which there were clinical symptoms. No complete survey of the subject has been offered since 1906. Such a survey appears to us timely.

In this article we propose to review the entire subject of intra-abdominal hernia, report a unique case and make conclusions based on the experience with our own case and on the records of previously reported cases. We believe that such information, concretely assembled, will be of value to others.

REPORT OF CASE

The patient was a 58 year old man, a cretin. He could not talk or write, and his mentality was about that of a 3 year old child. The persons who had him in their care noted that for the past few months he had suffered at irregular intervals from what were apparently intra-abdominal cramps, as he would grimace and hold his abdomen. His abdomen had for some years been somewhat protuberant, but lately the upper portion had become decidedly larger.

He was relatively active until three days before his admission to the hospital. At that time he complained that his belt was too tight, and he vomited an evening meal. After that he vomited "coffee ground" material several times. He had a copious bowel movement the morning prior to the onset of acute symptoms, three days before admission, but none afterward.

Examination on admission revealed that the abdomen was distended and tympanitic throughout. There was a large, soft, balloon-like protrusion filling the space between the left costal margin and the umbilicus. Some peristalsis was heard in the lower part of the abdomen.

From the Laboratories of Pathology and Radiology, Columbia Hospital.

The record of the case reported was made available by Drs. R. E. Morter and C. W. Long.

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The gastric contents were dark and sticky and gave a strong reaction for blood. The value for blood chlorides (as sodium chloride) was 511 mg. per hundred cubic centimeters after administration of chloride. The urine was normal. The leukocytes numbered 11,000 per cubic millimeter.

Roentgen examination was made, with a presumptive diagnosis of an obstructing malignant lesion at the outlet of the stomach. A flat plate of the abdomen was first made. This revealed a large collection of gas in the left upper quadrant of the abdomen, sharply limited by a well defined wall. There was some dilated small bowel in the right upper quadrant. An attempt to insert a Wangensteen suction tube into the stomach under the fluoroscope failed.

The next day a small amount of barium sulfate was given. The stomach, instead of being dilated as expected, was found to be smaller than usual and displaced backward, upward and to the right. The gaseous mass had become larger. The barium sulfate ran slowly through the small bowel, which was dilated in some

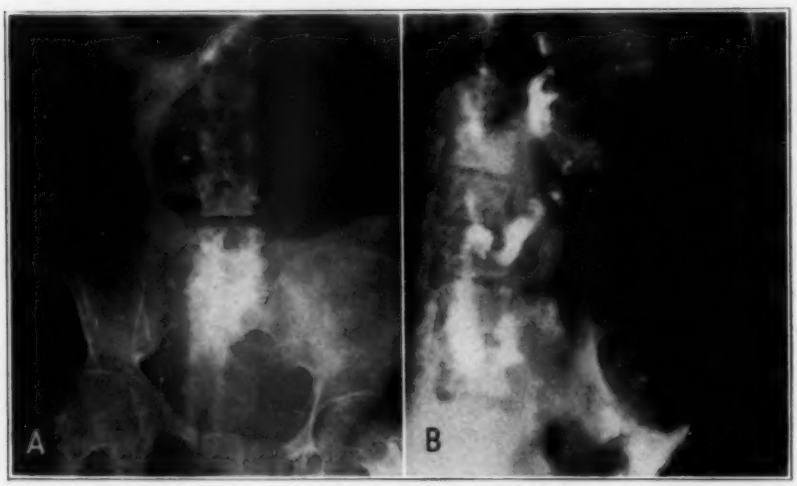

Fig. 1.—*A*, flat plate of the abdomen taken on admission of the patient to the hospital, showing a distended viscus in the left hypochondrium. This was thought at the time to be the stomach, distended with gas. *B*, roentgenogram taken a day later, after a small amount of barium sulfate had been administered. The gaseous accumulation was not in the stomach, but the stomach was displaced backward by it.

regions, and about twenty-four hours later was reported to have appeared in the stool. It was then deemed safe to give a larger amount by mouth. This was done, but no additional information was obtained until examination at the end of twenty-four hours, when thinly diluted barium sulfate was seen in the gas-filled sac. The sac was larger than before, and the barium sulfate suspension splashed around in it freely when the patient was turned or shaken.

A barium sulfate enema showed the colon to be in a relatively normal position except that its transverse portion was displaced upward and backward. The colon could not be examined well on the right side, but the hepatic flexure and the ascending colon seemed normal. The cecum was small but freely movable. Owing to the difficulties of the examination, the small bowel was not identified.

(This was unfortunate. The small bowel or the appendix should always be identified before a definite opinion is formed on an examination of the colon.) Dilated small bowel could be seen in the large sac, the size of which increased from day to day.

Roentgen examination was difficult and unsatisfactory because the patient was unable to help himself and because of his extremely low mentality. It was concluded that there was an obstruction in the lower part of the small bowel. The arrangement of the bowel suggested an internal retroperitoneal hernia, probably paraduodenal. The large, soft, balloon-like mass was thought to be due to distention of the lesser peritoneal sac, into which some part of the herniated bowel had perforated. It was recognized that the position of the stomach was opposed to this opinion, but the shape of the gas-filled mass suggested it.

The patient was under observation for several days, during which time he was not as ill as one would expect if an intestinal obstruction was present. A

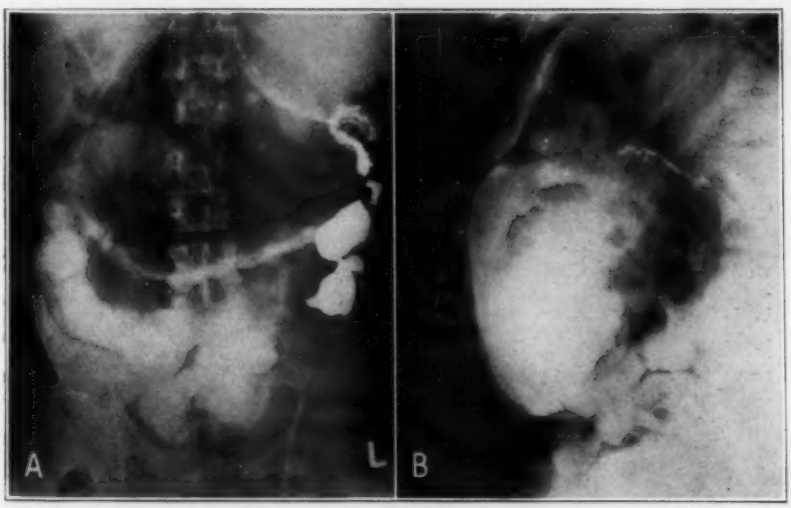

Fig. 2.—*A*, roentgen plate of the abdomen after twenty-four hours. The barium sulfate is distributed in dilated loops of small bowel. Note the barium water free in the large sac in the left hypochondrium. *B*, lateral view at this time, showing free barium solution in the large sac previously filled with gas.

preoperative diagnosis of intestinal obstruction, probably due to an internal hernia, was made.

At operation the abdomen was opened by an incision in the midline, and immediately a large, distended hollow viscus was seen. This was found to be the cecum, lying with its tip high under the left side of the diaphragm. It was enormously dilated and filled almost the entire upper portion of the abdominal cavity. It was fully 15 to 20 cm. in diameter. Gas was aspirated from it until it was decompressed. Abdominal exploration was difficult on account of the size of the cecum and the distended loops of small bowel. However, a ragged opening was noted in the mesentery of the small bowel, through which emerged the dilated cecum.

The ascending colon was retracted inward, and at its external side was a hole through which two loops of bowel passed. These were pulled out. Several

feet of small bowel and, later, the dilated cecum were withdrawn. The condition of the patient was such that accurate or prolonged exploration was impossible. The assistant noted, however, that in the anterior edge of the inner hernial opening he felt the pulsation of a good-sized artery as he held the hole open during reduction.

The patient's postoperative condition was good until the fifth day, when signs of peritonitis were noted. He died the following day.

Postmortem examination revealed significant changes. The entire peritoneum which carried the viscera was relaxed and mobile. The great mesentery was long,

Fig. 3.—Roentgenogram taken after a barium sulfate enema. The examination was inconclusive and unsatisfactory. Note the colon draped over the gas-filled mass.

and the ascending colon and cecum were markedly mobile. The transverse mesocolon was long, but the descending colon was closely attached to the posterior abdominal wall. The foramen of Winslow was obliterated. The lesser peritoneal sac was normal except that the leaf of the transverse mesocolon, which constituted its floor, was elongated and scarred by linear striae. There were no important paraduodenal fossae. The stomach and duodenum were normal. The great mesentery was bifurcated by a deep digitation 188 cm. from the duodenojejunal junction. The bowel above this point was normal, but distal to the

digitation it had a thickened wall. This thickened portion of the small bowel was 138 cm. long, and the loops were arranged together and were particularly adherent as if they had been contained in a sac.

There was a stroma 15 cm. in length extending almost the entire length of the outer leaf of the mesentery of the ascending colon. The inner leaf of this mesentery where it reflected onto the upper leaf of the great mesentery had a linear rent 6 cm. in length. This was definitely a tear, as there was no inversion of the serous lining which extended into the stoma previously mentioned. There was a sac extending into and distending the mesentery of the transverse colon as far as the greater curvature of the stomach.

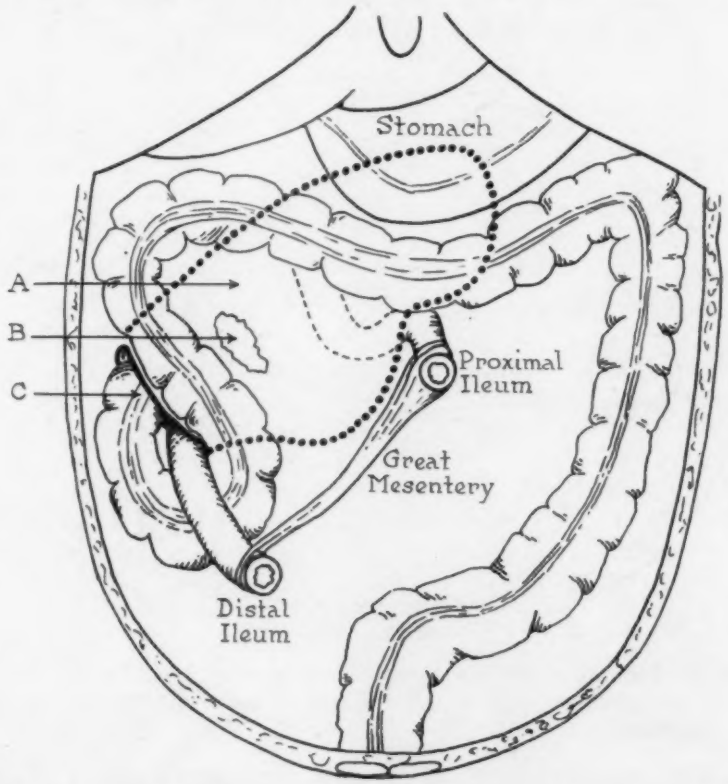

Fig. 4.—*A*, position and extent of hernial sac; *B*, rent in the inner leaf of the mesentery of the ascending colon, through which came the cecum; *C*, stoma in the outer leaf of the mesentery of the ascending colon, through which the hernia occurred.

Two small vesicles filled with slightly viscid clear fluid on either side of the trachea represented the thyroid.

INTERPRETATION OF CASE

The patient apparently had some type of internal hernia which was reduced at operation. An extended investigation was not expedient at

that time. When necropsy was performed the contents of the hernial sac had been withdrawn. An effort was made to reconstruct conditions as they existed prior to operation.

Certain facts were definite:

1. There was a large stoma in the external aspect of the mesentery of the ascending colon, with peritoneum reflected into the retroperitoneal space.
2. The cecum was very mobile because of an elongated mesentery.
3. Many of the peritoneal structures were remarkably relaxed, and the mesenteries were long.

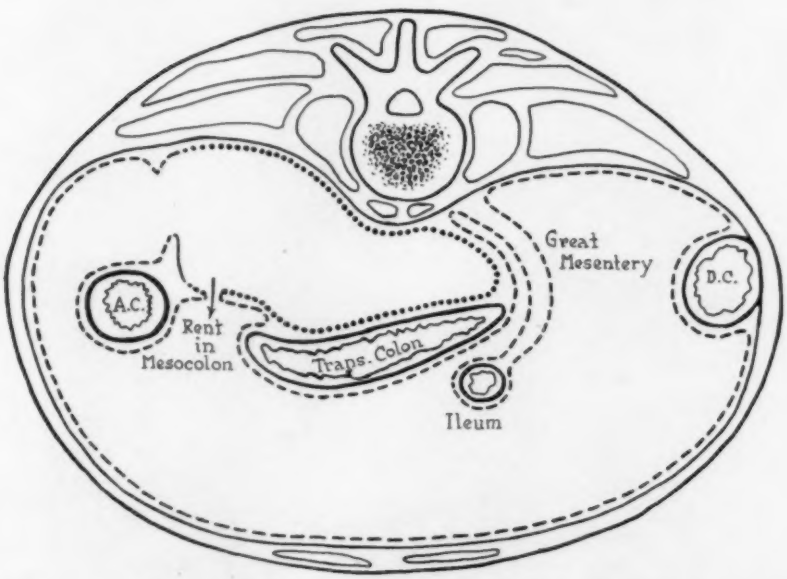

Fig. 5.—Diagram of a transverse section of the body at the level of the stoma, showing the position of the stoma, the rent in the mesentery and the extent of the hernial sac.

4. There was a rent in the inner leaf of the mesentery of the ascending colon at the point where this leaf was reflected onto the greater mesentery.
5. The great mesentery was bifurcated, and the lower 138 cm. of the small bowel was adherent in a configuration suggesting confinement in a bag.

From these known facts and from the information gained by roentgen examination and by operation it seems logical to make the following interpretation of the conditions that existed prior to operation. There was a hernial sac extending into the retroperitoneal region, the opening

of which was in the lateral aspect of the mesentery of the ascending colon. This sac contained the cecum, the appendix and 138 cm. of small bowel, extending from the ileocecal valve to the digitation in the mesentery previously mentioned The sac ruptured anteriorly through the peritoneum, where the ascending mesocolon was reflected on the great mesentery. The cecum had come out through the hole and had become enormously dilated so that it filled the whole left side of the abdomen.

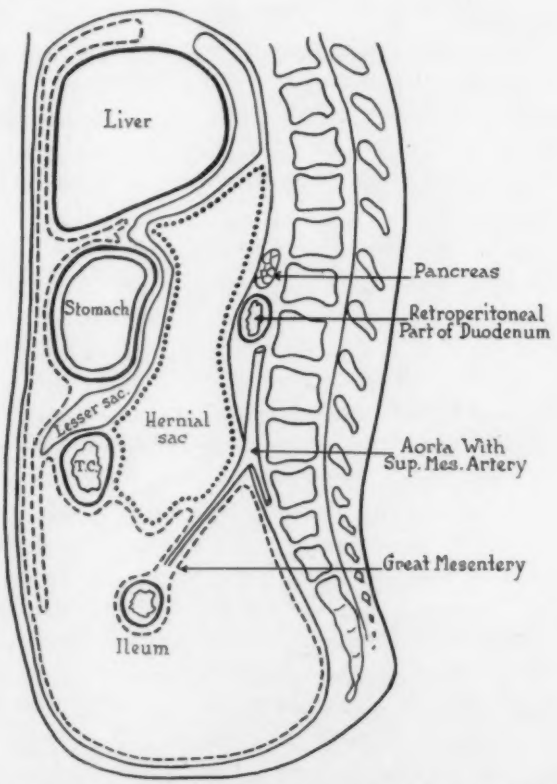

Fig. 6.—Sagittal diagram of the body, showing the position of the hernial sac.

It would seem that the patient had a congenital redundancy of the mesenteric structures. The hernia had probably been present for a considerable time, and perhaps the cecum broke through the wall at the onset of the present acute illness. The cecum became partially obstructed where it protruded through the rent in the mesentery; gas could get in but not out, which caused the cecum to become tremendously dilated.

The patient, then, had an internal hernia, rupture of the wall of which was followed by extrusion of the cecum from the hernial sac into the abdominal cavity with resultant partial intestinal obstruction.

Cullen reported a hernia in which the intestine entered the mesocolon of the ascending colon from its internal aspect. Short reported a case in which loops of the terminal part of the ileum entered a stoma from the lateral aspect at the junction of the cecum and the ascending colon. With the exception of a brief case report by Hacker, no description of a hernia entering the mesentery on the external aspect of the ascending colon proper has been found.

COMMENT

Classification of Hernias.—Some of the reports in the literature contain incomplete descriptions of hernias, and the descriptions in others indicate that the hernias did not fit accurately into the described types. We endeavored from the information available to classify these hernias. The establishment of criteria was necessary. A hernia the stoma of which pointed upward and to the left and the sac of which dissected to the right beneath the superior mesenteric artery and entered chiefly the ascending mesocolon was considered a right paraduodenal hernia. A hernia the stoma of which pointed upward and to the right and the sac of which passed beneath the inferior mesenteric vein and left colic artery and came to occupy chiefly the descending mesocolon was considered a left paraduodenal hernia. A hernia the stoma of which pointed downward and the sac of which dissected the peritoneum of the left side of the abdomen from the posterior parietes was considered an infraduodenal hernia. Needless to say, when the entire peritoneum was dissected from the posterior parietes we had only the configuration of the stoma for classification. The pericecal hernias included all hernias about the cecum, whether they were retrocecal, pericecal or subcecal (occurring as a pocket of peritoneum beneath the cecum). The ileocolic hernias were those which occurred in the angle between the ileum and the ascending colon. The ileoappendical hernias were those which occurred at the angle of the appendix, the cecum and the ileum. The prevesical hernias were those which occurred anterior to the bladder on either side of the remnant of the urachus and between the obliterated hypogastric arteries. The classification of other hernias should be self evident.

Most intra-abdominal hernias occur in or about the paraduodenal fossae, into the transverse mesocolon or through the foramen of Winslow.

Location and Incidence.—Table 1 is a compilation of the locations of the reported hernias and indicates the sex of the patients so far as information on that was available.

These statistics are based on cases in which the diagnosis was proved. Cases in which there were unconfirmed roentgen diagnoses were not

included. Cases in which hernia was associated with a previous surgical operation were not included. Cases of which hernia pushed into other cavities or was destined to terminate outside the abdominal cavity were omitted. The study was limited to instances in which hernia arose within the abdomen and appeared destined to remain within the abdomen.

Miscellaneous cases were those in which the hernia occurred in one of the following ways: behind an aberrant middle colic artery which arose from the common iliac artery; into the rectum; back of the pelvic peritoneum; into the properitoneal fat low on the anterior abdominal wall; into the mesentery of a mobile duodenum; back of the vitelline duct; through the mesentery of the falciform ligament of the liver; by a loop of small bowel pushing through a hole in an adjacent loop, and (in 5 cases) by retroposition of the transverse colon, the colon passing through the root of the mesentery.

TABLE 1.—*Incidence of Intra-Abdominal Hernia at Various Sites According to Sex as Recorded in the Literature*

Site	Cases	Males	Females	Sex Not Determined
Left paraduodenal	138	46	18	74
Transverse mesocolon	60	15	34	11
Right paraduodenal	47	28	6	13
Mesenteric	38	21	9	8
Foramen of Winslow	37	19	6	12
Pericecal	31	19	4	8
Intersigmoid	28	20	7	1
Broad ligament	18	..	18	..
Ileoappendicular	16	13	3	..
Ileocolic	14	8	6	..
Prevesical	13	3	..	10
Inferior duodenal	5	2	2	1
Great omentum	5	3	1	1
Ascending mesocolon	4	4	..	0
Miscellaneous	13	..	..	..
Totals	467	200	116	183

More of the intra-abdominal hernias occurred in men than in women, but hernia of the transverse mesocolon was found oftener in women. An intra-abdominal hernia occurring in the pelvis of a woman is almost certain to be into the broad ligament.

The regional distribution of the reported hernias is summarized in table 2. There it is indicated that hernia is most frequently found about the duodenum, underneath the transmesocolon. The foramen of Winslow is frequently mentioned as a common site for intra-abdominal hernia, but from the table it will be seen that this site was not concerned in a high percentage of cases. It is further stated that hernia into the foramen of Winslow is associated with an abnormally mobile cecum. In this study that statement was found erroneous.

A roentgen diagnosis of a sizable intra-abdominal hernia may be made with some degree of accuracy, but it would seem that the roentgen

determination of the site of the stoma is not much more accurate than a statistical guess. The roentgen features of right paraduodenal hernias were well described by Exner. From the reports of the various types of hernia which were diagnosed by roentgenograms, certain roentgen signs seem to have been present. There was a disturbance of the normal intestinal arrangement. In some cases the displaced intestines remained crowded together as if contained in a bag. There were dilatation and loss of mobility of the affected loops of bowel associated with a varying degree of stasis.

Mechanism.—Intra-abdominal hernia may occur at almost any age and at almost any place in the abdomen. The only supports for the peritoneal reflections are the parietes, the vessels and the nerves. Most articles elaborate on the location of various fossae, but it must be pointed out that hernia may take place at any point where the peritoneum is not defended by the parietes or by the vessels and nerves in the mesentery. It would appear that both fossa and hernia are expressions

TABLE 2.—*Regional Distribution of Reported Hernias*

Region	Number	Percentage
Paraduodenal	250	53
Pericecal and terminal ileum	61	13
Perimesenteric	38	8
Foramen of Winslow	37	8
In the pelvis	31	7
In the sigmoid region	28	6
Miscellaneous	22	5
Total	467	100

of regional peritoneal weakness rather than that the fossa acts in a causative way in the development of a given hernia. At least, the stomas of the reported hernias did not always conform precisely to the described peritoneal fossae.

In the case reported in this paper the hernia broke through the hernial sac back into the abdominal cavity. With the more common hernias in and around the paraduodenal fossae this rarely occurs, but it not infrequently occurs with the other varieties, particularly those entering the mesenteries or the foramen of Winslow.

The controversy as to whether hernias are congenital or acquired cannot be decided in individual cases. Certain facts, however, may be stated. Some hernias, particularly left paraduodenal, are found in newborn infants. Some hernias are dependent on abnormal mesenteries, mesenteric holes and aberrant vessels. Retroposition of the transverse colon could occur only during development of the peritoneal reflections. However, intra-abdominal hernias occur after surgical procedures, particularly those involving the transverse mesocolon. It seems certain that both mechanisms are responsible for intra-abdominal hernias.

Treatment and Prognosis.—Surgical treatment of intra-abdominal hernia is usually indicated, and recently the results here compare favorably with those obtained with other hernias.

Reduction of the hernia is about all that is necessary. Elaborate efforts to close the opening, unless there is a large hole directly through a mesentery, are usually not necessary, as stomas are usually roughened, and agglutination of adjacent folds of peritoneum occurs quickly. In only 1 case was a recurrence noticed; it occurred through a large

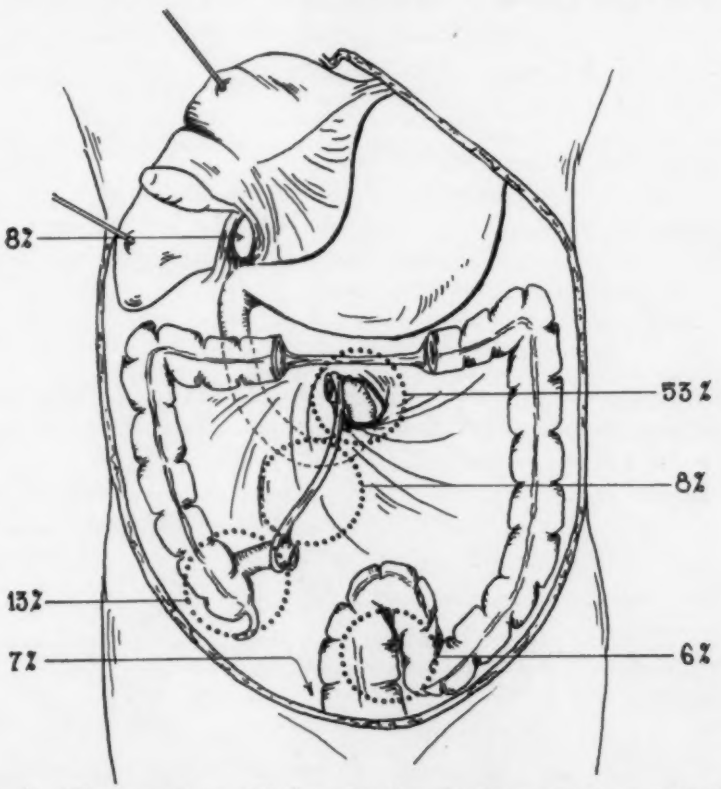

Fig. 7.—Diagram of the abdomen, showing the frequency (expressed in percentage) of intra-abdominal hernias in various regions of the abdomen.

foramen of Winslow, but it caused no symptoms and was observed incidentally at postmortem examination.

The general condition of the patient, the condition of the circulation of the involved intestine and the amount of injury to the intestinal wall are the important points in surgical prognosis.

The tables indicate to the surgeon and the pathologist that in most instances the stoma of intra-abdominal hernia will be found by lifting up the transverse mesocolon and exploring the paraduodenal region.

They show also that hernia in the broad ligament and hernia through the transverse mesocolon are important in women and that hernia in the pelvis is almost always in the broad ligament. The information contained in the tables should assure an intelligent exploration of the abdomen of a patient of either sex at operation or at postmortem examination.

In attempting to determine the exact site of the stoma, its relation to the left colic artery and the inferior mesenteric vein or to the superior mesenteric artery is important. Finally in exploration of the abdomen for internal hernia one should always consider abnormal intestinal rotations and aberrant vessels.

BIBLIOGRAPHY

A classified bibliography has been prepared. This includes general reviews of the whole subject and special reviews of hernia occurring in special locations. Some important roentgen studies are included. By reference to the bibliography, excellent articles on all forms of intra-abdominal hernia can be obtained.

SUMMARY

An unusual case of retroperitoneal hernia occurring in the external leaf of the mesentery of the ascending colon is reported.

The literature is reviewed, and tables are presented to show the location and frequency of all forms of intra-abdominal hernia.

The roentgen diagnosis of the condition is fairly accurate, but the roentgen determination of the site of the stoma is not reliable.

The treatment is surgical, and good results follow simple reduction of the hernia.

A classified bibliography is presented.

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HEMANGIOMA OF THE COLON

REPORT OF A CASE

C. F. SAWYER, M.D.
CHICAGO

Tumors of the blood vessels are numerically important among the neoplasms found in the human body. Many of these are benign angiomas of the body surfaces and merit little special clinical attention.

Hemangiomas of the capillary, or simple, type are characterized by an intricate arrangement of capillary blood vessels embedded in a variable amount of connective tissue stroma. They are usually congenital and may involve any part of the body except the cornea and cartilages. Although benign, they may be associated with malignant disease. They may be circumscribed or diffuse.

Cavernous hemangiomas are composed of blood spaces of irregular shapes and sizes which communicate with each other and are supported by a connective tissue framework. The spaces are lined with endothelium. The tumors are sometimes pulsating and erectile.

Many pathologists do not consider hemangiomas of either type as true tumors, classifying them instead as malformations. This is because many hemangiomas are supposed to lack the power of independent proliferation. This is not true of a third type, however, which may show either the capillary or the cavernous arrangement or both in the same tumor. The hypertrophy is mostly evident in proliferation of the endothelial cells. Although not always encapsulated, most of these neoplasms are benign. Some of them become definitely malignant and are classified as endothelial sarcomas. Even though benign, they may cause local destruction through their manner of extension (by infiltration of the adjacent tissues) and by their growth along the blood vessels.

Geschickter and Keasbey [1] classified 570 hemangiomas as regards distribution in the body. Three hundred and seventy of these were peripherally located. Sixty-five were grouped under "special locations," including the bones, the muscles and the central nervous system. The remaining 135 were included in a "central group," 109 occurring in the liver, 16 in the heart valves and only 10 in peritoneal or retroperitoneal structures, namely, the mesentery, the kidney, the spleen and the gastrointestinal tract. If these statistics represent a fair cross section of the

1. Geschickter, C. F., and Keasbey, L. E.: Tumors of Blood Vessels, Am. J. Cancer **33**:568-591 (March) 1935.

distribution of hemangiomas, it is apparent that the tumors are rarely found in the intestines.

In 1930, McClure and Ellis [2] collected 24 cases of hemangioma of the intestines from the literature and reported 1 of their own. In 14 of these cases the tumor was single, and in 11 there were multiple hemangiomas. The tumors were distributed as follows: 2 in the duodenum, 15 in the small intestine below the duodenum, 1 in the colon, 4 in the rectum and 2 in the entire bowel. The location of 1 was not stated.

Bargen and Dixon [3] said: "This is perhaps the rarest type of tumor in the large bowel." They mentioned the occurrence of hemangiomas as follows: 1 in the wall of the cecum, discovered in an operation for

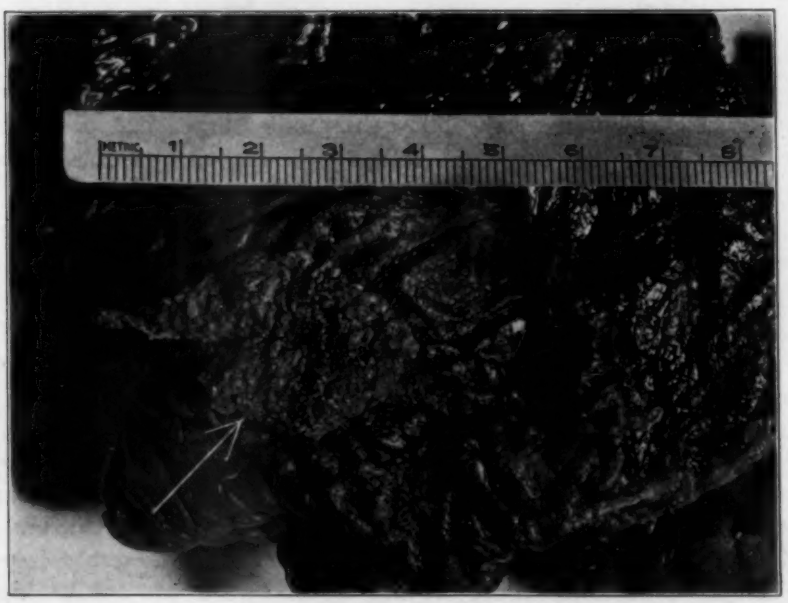

Fig. 1.—Photograph of the gross specimen. The arrow indicates the hemangioma.

gallstones; 1 in the splenic flexure, with a preoperative diagnosis of carcinoma, and 2 in the rectosigmoid region, with a preoperative diagnosis of polyp.

These tumors usually arise in the submucosa. They may grow toward the lumen of the intestine, become ulcerated and cause hemorrhage. They may grow to such a size in the lumen as to cause mechanical obstruction. They may infiltrate the muscle wall and by ringlike contraction and constriction of the lumen cause an intestinal obstruction.

2. McClure, R. D., and Ellis, S. W.: Hemangiomata of Intestines, Am. J. Surg. **10**:241-244 (Nov.) 1930.

3. Bargen, J. A., and Dixon, C. F.: Uncommon Tumors of the Large Intestine, Am. J. Digest. Dis. & Nutrition **1**:400-403 (Aug.) 1934.

Such growths may be symptomless, and no doubt some are not discovered. A sign of hemorrhage is the most frequent finding. This may be only a slight staining with blood or a massive hemorrhage. Signs of intestinal obstruction, either acute or chronic, may or may not be associated with the hemorrhage. Infrequently hemangiomas may be found elsewhere, for example, in the skin, and may suggest similar lesions in the bowel. Roentgen examination is likely to confirm obstructive signs

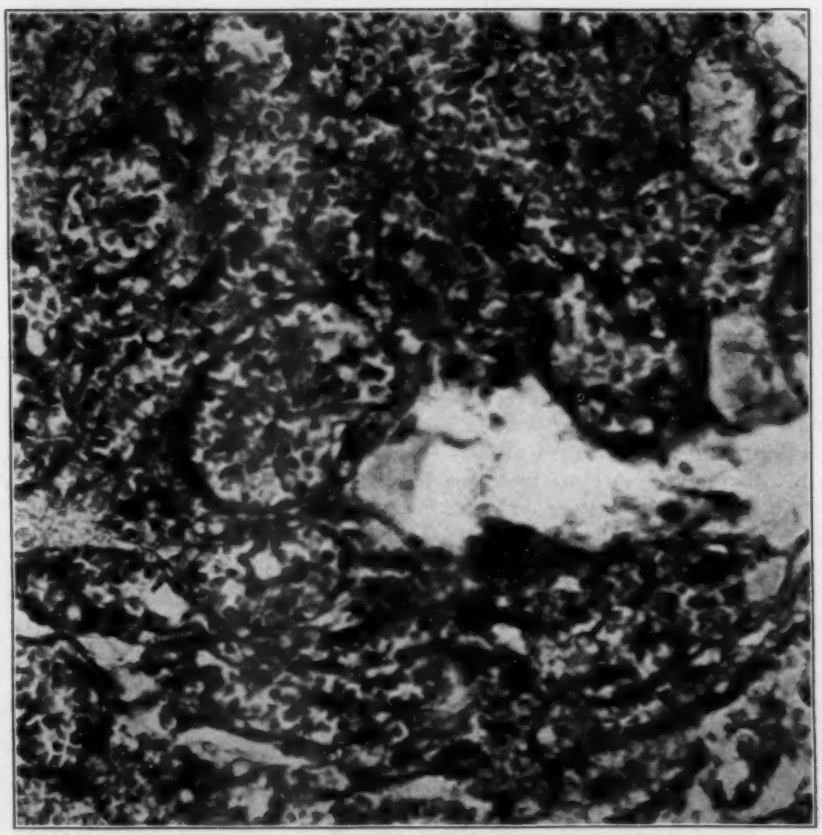

Fig. 2.—Microscopic section through the tumor, showing well defined capillaries filled with red cells. Note the masses of red cells between the capillaries (hemorrhage).

but is not of much value in differentiation of the condition from carcinoma.

In the presence of obstruction, surgical treatment is indicated. The mortality is high, as was indicated by Brown [4] in his review of 20 cases

4. Brown, A. J.: Vascular Tumors of the Intestine, Surg., Gynec. & Obst. **39**:191-199 (Aug.) 1924.

of hemangioma of the intestinal tract below the stomach. Of this number, death occurred in 14 and recovery in 5. In 1 the result was not stated. This report covered a period of seventy-five years. Modern surgery should make a better showing.

REPORT OF CASE

J. G., an unmarried steel worker aged 55, entered Mercy Hospital March 21, 1935, in the service of Dr. F. M. Drennan. His complaints at the time of admission were: severe intermittent pain in the lower part of the abdomen; no effective bowel movement in seven days; some blood noted in the stools previously, and loss of 10 pounds (4.5 Kg.) in weight. For three and one-half months he had had attacks of cramplike pain in the lower part of the abdomen, associated with stubborn constipation. The attacks at first occurred at intervals of about one week, and relief was obtained with enemas. Gradually the attacks became more severe and occurred at shorter intervals. When an enema was given the pain was at first increased, and then, with the flushing out, it largely disappeared. At first the relief lasted for several days, but later it lasted only for a few hours and the patient could not take as much water as formerly. He had never had a black stool, but recently he had noted a little red blood. Loss of 10 pounds (4.5 Kg.) in weight had occurred in the last year, but his appetite had been fair until the last few days. He stated that ever since the Spanish-American War he had been bothered by constipation and had taken a laxative nearly every day. He rarely had a headache. His eyes were good. He was somewhat deaf. He had no trouble with his nose, throat or chest except for an occasional cough. There was no epigastric distress. There were no symptoms referable to the genito-urinary tract. About two years previously he had had pain in both elbows. This was relieved when his teeth were removed. For twenty years after a strain incurred while wrestling he had had occasional pain in the region of the right hip, but this was less troublesome than before the extraction of his teeth.

Examination of the head, neck and chest gave essentially negative results. The abdomen, though not distended, was tense, and there was apparent tenderness on the left side. There was a suggestion of a mass to the left of the umbilicus. The liver, spleen and kidneys were not palpable. Digital rectal examination gave negative results. The blood count showed 5,370,000 red cells and 9,450 white cells per cubic millimeter, with 70 per cent hemoglobin. The Wassermann reaction of the blood was negative. Urinalysis gave essentially negative results. Of seven stools obtained by enemas, examination showed no blood in three; in the other four a variable amount was present (up to 4 plus). Roentgen examination after a barium sulfate enema caused considerable distress. The rectal ampulla was larger than normal. In the upper part of the sigmoid flexure and the lower part of the descending colon a definite obstruction was noted, which allowed only a thin stream of barium to pass through. At the point of obstruction there was apparently a definite, palpable mass which was tender to pressure. A roentgenogram taken immediately afterward revealed a definite filling defect in this area.

The patient was referred by Dr. Drennan for operation on April 1. An incision was made near the outer border of the left rectus muscle. A constricting neoplastic mass was found in the lower part of the descending colon. It was not fixed posteriorly or adherent to other structures. There were many hard, shotlike glands in the mesentery. No pathologic change was noted in the liver or other abdominal organs. By means of a Mikulicz exteriorization procedure the involved loop of

bowel was free and delivered outside the abdominal wall. The entire mass was removed by cautery the following day. The patient's convalescence was uneventful, and he left the hospital May 8 with an almost normally functioning bowel. A small fistulous opening was successfully repaired some months later.

Pathologic Report.—The section of the large bowel examined was 21 cm. long. Nine centimeters of this section of bowel was a healthy pink, and this normal area was sharply demarcated from the remaining 12 cm. of densely edematous and dark red hemorrhagic portion. Six centimeters from the end of the latter portion there was a friable tumor mass 2.5 cm. in diameter, elevated to a height of 5 to 7 mm. It had a broad base and was sharply demarcated. The surface was friable and somewhat papillomatous. It was of the same dark red color as the intestine. Microscopic examination of the tumor revealed a capillary hemangioma of the mucosa. The tumor with the rest of the dark red portion of the intestine had undergone hemorrhagic infarction. The masses along the mesentery were chronically inflamed lymph nodes, and some had undergone hemorrhagic degeneration. The diagnosis was capillary hemangioma of the bowel with hemorrhagic infarction.

COMMENT

The tumor in this case simulated an obstructing carcinoma of the large bowel in almost every particular. The entire absence of blood in several stools and its presence in fairly large amounts in two others would seem the only discrepancy. The hemorrhage has been the prominent finding in the few cases of hemangioma of the large bowel previously reported. This case, more than any other, emphasizes the obstructive symptoms.

EFFECTS OF ESTROGEN ON BONES, JOINTS AND LIGAMENTS OF CASTRATED GUINEA PIGS

CHARLES J. SUTRO, M.D.
AND
LEO POMERANTZ, B.S.
NEW YORK

It has been shown that estrogens cause definite gross anatomic alterations in the joints of the pelvic ring in the guinea pig.[1] Hisaw[2] has demonstrated experimental relaxation of the pubic symphysis with the relaxative hormone of the corpus luteum. Little attention, however, has been paid to the minute histologic changes occurring at the pubic symphysis during the transformation. Furthermore, similar correlative histologic studies of other bones and joints of guinea pigs are lacking.[3]

In the light of these facts it seemed of interest to investigate the effects of subcutaneous injections of estrogen[4] in mature castrated guinea pigs on (1) the tissues of the pubic symphysis and the sacroiliac

From the Laboratory Division of the Hospital for Joint Diseases.

1. de Fremery, P.; Kober, S., and Tausk, M.: Erweiterung der Symphysis pubis des weiblichen Meerschweinchens durch Menformon, Acta brev. Neerland. **1**:146, 1931. Tapfer, S., and Haslhofer, L.: Hormonale Weiterstellung des Beckens im Tierversuch, Arch. f. Gynäk. **159**:313, 1935. Gardner, W. U.: Sexual Dimorphism of the Pelvis of the Mouse: The Effect of Estrogenic Hormones upon the Pelvis and upon the Development of the Scrotal Hernias, Am. J. Anat. **59**:459, 1936.

2. Hisaw, F. L.: The Influence of the Ovary on the Resorption of the Pubic Bones of the Pocket Gopher, Geomys Bursarius (Shaw), J. Exper. Zoöl. **42**:411, 1925; Experimental Relaxation of the Pubic Ligament of the Guinea Pig, Proc. Soc. Exper. Biol. & Med. **23**:661, 1926; Experimental Relaxation of the Symphysis Pubis of the Guinea Pig, Anat. Rec. **37**:126, 1927; The Corpus Luteum Hormone: Experimental Relaxation of the Pelvic Ligaments of the Guinea Pig, Physiol. Zoöl. **2**:59, 1929. Fevold, H. L.; Hisaw, F. L., and Meyer, R. K.: The Relaxative Hormone of the Corpus Luteum, J. Am. Chem. Soc. **52**:3340, 1930; Isolation of the Relaxative Hormone of the Corpus Luteum, Proc. Soc. Exper. Biol. & Med. **27**:604, 1930; Physiology of the Corpus Luteum, in Allen, E.: Sex and Internal Secretions, Baltimore, Williams & Wilkins Company, 1932, p. 499.

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4. Estradiol benzoate in sesame oil was supplied by the Schering Corporation.

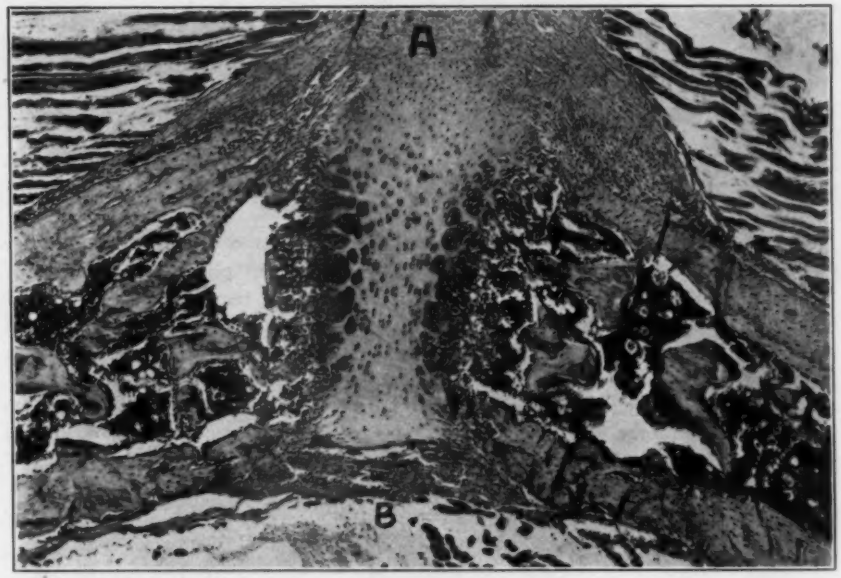

Fig. 1.—Photomicrograph of a normal pubic symphysis. *A*, anterior ligament; *B*, posterior ligament.

Fig. 2.—Photomicrograph of a sacroiliac joint. Note the interdigitating ligamentous bands (arrow). × 20.

joints in situ, (2) autogenous transplanted segments of the pubic symphysis with attached ligaments, and (3) the capsular tissues of the major joints.

METHOD

Twelve male guinea pigs, each weighing approximately 400 Gm., were castrated under general anesthesia. In 8 animals the lower caudal half of the pubic arch, consisting of parts of the right and left pubic rami with the attached muscles and ligaments, were removed and transplanted into an artificial pocket made in the abdominal wall. In the remaining 4 the entire pubic arch was left in situ. Four additional guinea pigs served as controls, undergoing neither castration nor transplantation and receiving no injections of estrogen. The 12 castrated guinea pigs were divided into three groups of 4 animals each. The experimental conditions in the three experimental groups are given in the accompanying table.

At the end of the experiments the animals were killed with ether and roentgenographed. The original and transplanted portions of the pubic symphysis were

Experiments with the Injection of Estrogen in Guinea Pigs

Duration of Experiment, Days	Total Estrogen, Rat Units
Group 1 (testes removed; no transplantation; injection of estrogen)	
28	12,000
31	23,000
60	51,000
80	60,000
Group 2 (testes removed; transplantation; no injection of estrogen)	
28	None
31	None
60	None
80	None
Group 3 (testes removed; transplantation; injection of estrogen)	
28	12,000
31	23,000
60	49,000
80	60,000

removed, roentgenographed, fixed in Helly's fluid [5] and sectioned. Sections were taken also from the skull (including the symphysis menti and the incisors), sacroiliac articulations, hip, knee and vertebral column.[6] All sections were embedded

5. Helly's fluid consists of potassium bichromate, 2.5 Gm.; mercury bichloride, 5 Gm., and water, 100 cc. To 90 cc. of this solution 10 cc. of a 40 per cent solution of neutral solution of formaldehyde U. S. P. is added just prior to the fixation of the tissues.

6. To realize the effects of the injections of estrogen, it is necessary to be familiar with certain fine points in the anatomy of the pubic symphysis and sacroiliac joints of the male guinea pig. The pubic bones are separated by a sheet of hyaline cartilage. The cartilage rarely shows cracks or fissures, especially if the animal is young. The pubic bones are held together by the thick anterior ligament and the thin posterior ligament (fig. 1). Elastic fibers extend from the periosteum of one bone through the anterior and posterior ligaments respectively to the opposite bone. The sacroiliac joints consist of two parts, the anterior, or true, joint and a posterior segment consisting of interdigitating cross bands of ligaments. These bands insert into the elastic layer of the periosteum of the sacrum and ilium. Numerous thin-walled blood vessels are observed between these fibrous bands (fig. 2).

in paraffin and stained with hematoxylin and eosin. In addition, some of the preparations were stained for elastic fibers.

RESULTS

GROUP 1 (castration; no transplantation; injections of estrogen).—In this group the subcutaneous injections of estrogen induced no grossly obvious change in the

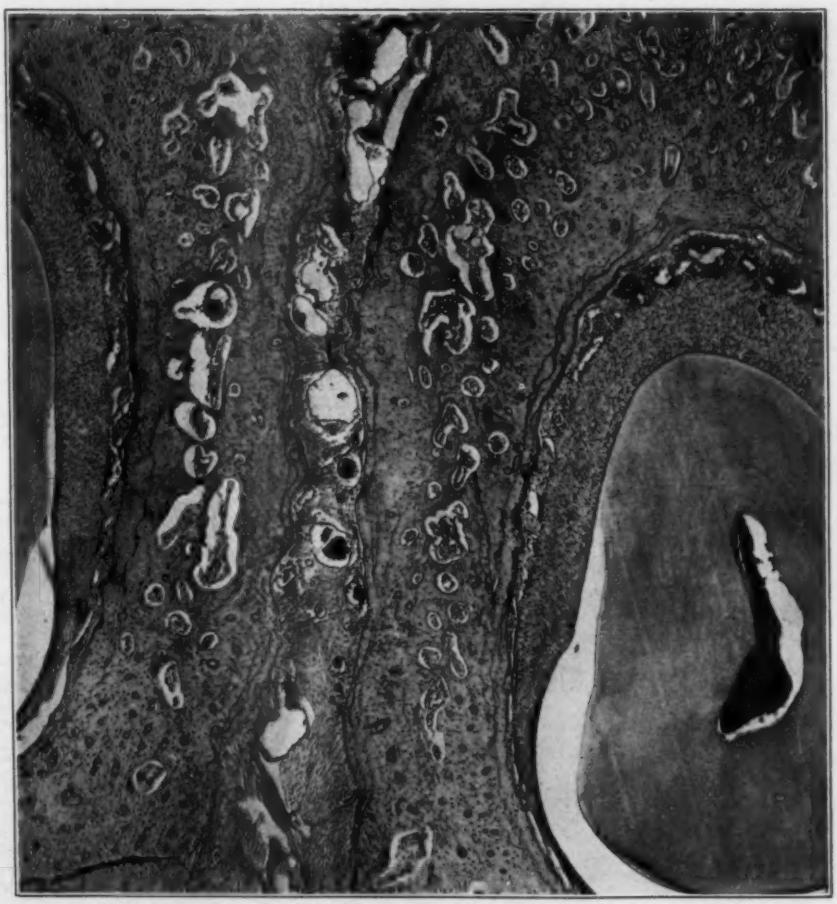

Fig. 3.—Photomicrograph of the symphysis menti. The structure shows no alterations following the subcutaneous injection of 51,000 rat units of estrogen over a sixty day period. × 30.

capsules of the hip or knee joints. The results were negative also in the symphysis menti (fig. 3), the frontal bones, the joints of the vertebral column, the sacroiliac articulations and the incisors. The epiphysial cartilage plates of the long bones appeared to have been closing somewhat prematurely. The roentgenograms revealed no striking alterations in the density of the skeleton.

In the symphysis pubis, however, definite alterations were encountered in one guinea pig after as little as 23,000 rat units had been given over a period of

Fig. 4.—*A*, photomicrograph of a section through the untransplanted pubic symphysis, showing thickening and hypercellularity of the posterior ligament (*P*). Note the cracks in the interpubic cartilage. The animal received 23,000 rat units of estrogen over a period of thirty-one days. × 35. *B*, photomicrograph of another section of the same pubic symphysis, disclosing marked thickening and hypercellularity of the posterior ligament (*P*). Note the resorption of the posterior cortices. × 35.

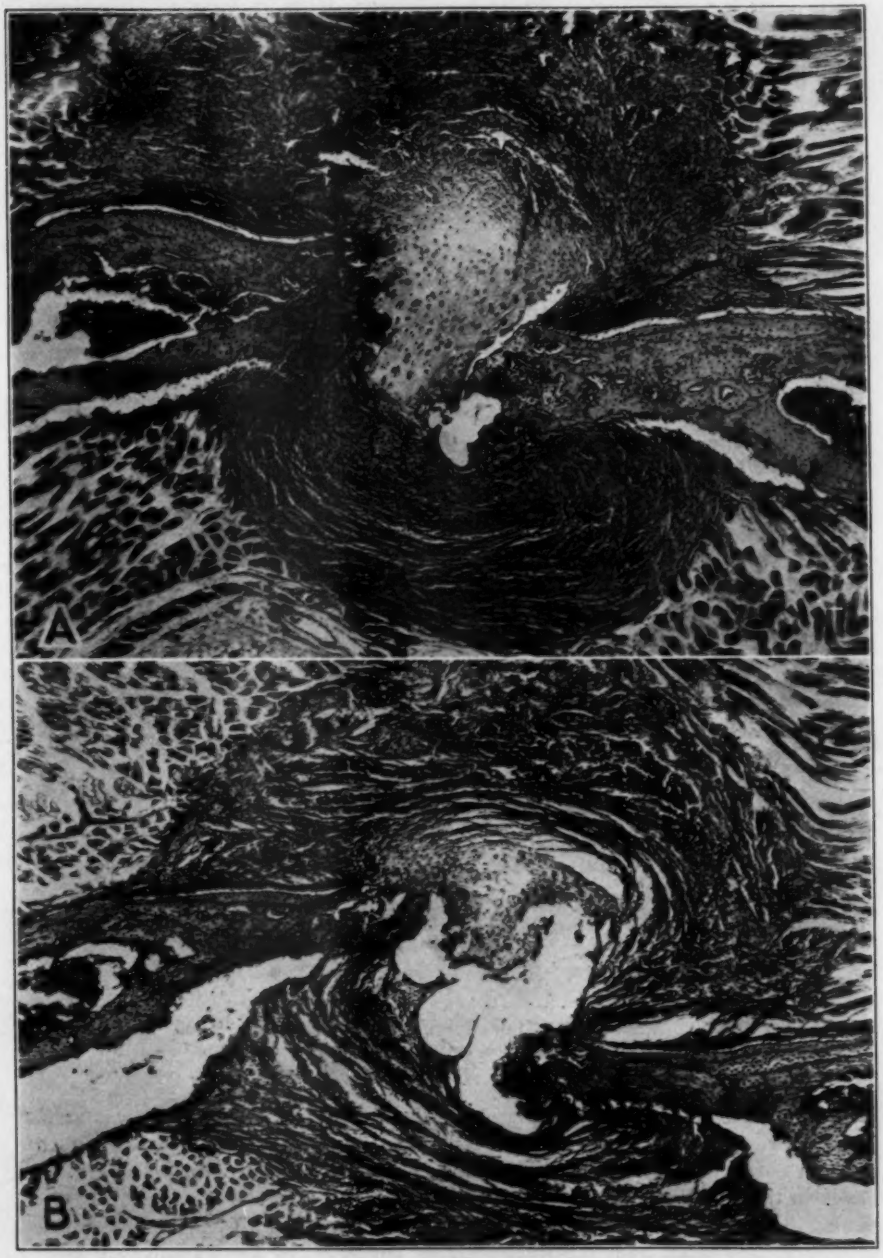

Fig. 5.—*A*, photomicrograph of a section of the untransplanted pubic symphysis, showing thickening and hypercellularity of both the anterior and the posterior ligaments. Note the lytic changes in the interpubic cartilage. The animal received 51,000 rat units over a period of sixty days. × 35. *B*, photomicrograph of another section of the same pubic symphysis, showing advanced lytic changes of the interpubic cartilage, with a posterior displacement of the right pubic bone. × 35

thirty-one days. The posterior ligament became thickened and hypercellular and rapidly replaced the interpubic cartilage. The latter underwent degeneration resulting in fissures and small cysts. The pubic bone bore evidence of resorption even on its posterior cortex (fig. 4). In another animal, which received 51,000 rat units of estrogen over a period of sixty days, the advanced lytic changes in the pubic symphysis had caused a definite separation of the pubic bones, with a posterior displacement of one of them (fig. 5). In an animal which received 60,000 rat units of estrogen additional changes were observed. The anterior cortices of the pubic bones showed resorption, and the elastic fibers in the posterior pubic ligament were fibrillated, cracked and widely scattered.

GROUP 2 (castration; transplantation of part of the pubic arch; no injection of estrogen).—In the 4 animals of this group no significant changes were observed

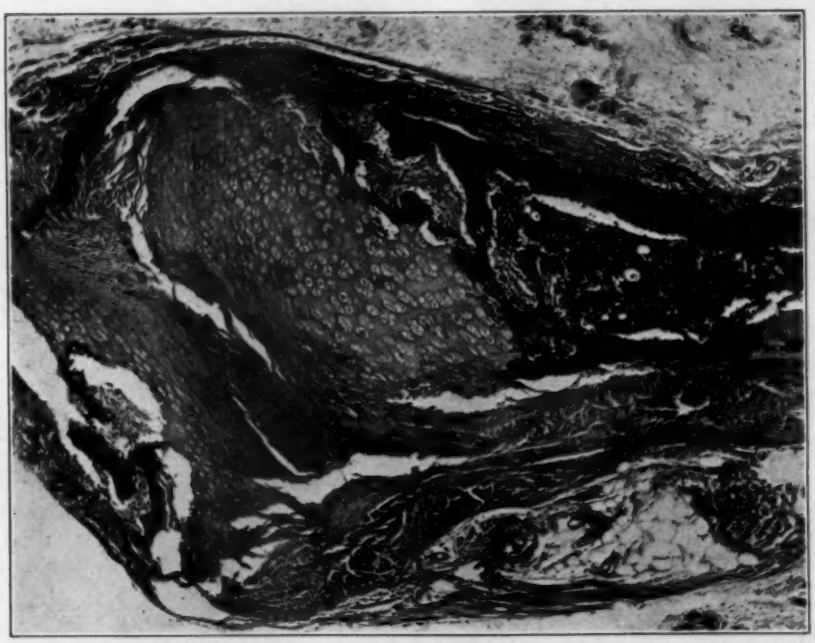

Fig. 6.—Photomicrograph of the transplanted portion of a pubic arch, showing partial necrosis of the interpubic cartilage. The anterior and posterior ligaments present no striking alterations. The animal received no injections of estrogen. The transplant was eighty days old. × 30.

in the ligaments or bones of the original, untransplanted segment of the pubic arch. The posterior ligaments showed some reparative thickening. In the animal killed at about twenty-eight days the transplanted piece was largely necrotic. The growth plates in the transplanted segments of the pubic bones were inactive. No demonstrable alterations were observed in the posterior ligaments. In the animal killed thirty-one days after transplantation some of the nuclei of the transplanted pubic cartilage appeared to be alive, and there was considerable evidence of transformation and rebuilding of the dead cortical bone. The intertrabecular marrow spaces had been undergoing fibrosis. In one of the preparations the posterior ligament was slightly cellular. Another transplant, examined eighty days after implanta-

tion, showed almost complete acellularity of the ligaments. Most of the interpubic cartilage was necrotic (fig. 6).

GROUP 3 (castration; transplantation of part of the pubic arch; injections of estrogen).—The transplanted segment of the pubic arch displayed nothing unusual after thirty-one days, even when the animal had received 23,000 rat units of estrogen. The original, untransplanted portion of the arch showed thickening of the posterior ligament and active resorption of the posterior portion of the interpubic cartilage. Another transplant, examined sixty days after implantation in the case of an animal which had received 49,000 rat units of estrogen, revealed

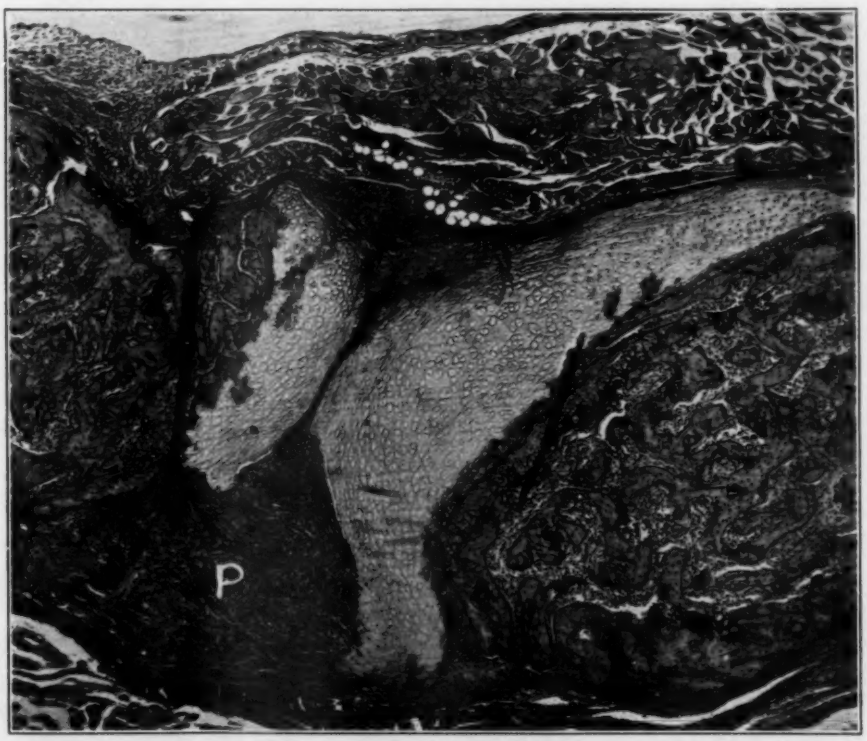

Fig. 7.—Photomicrograph, × 15, of the transplanted portion of the pubic arch. Note the thickening and hypercellularity of the posterior ligament (*P*). Note also the necrosis and resorption of the interpubic cartilage. The pubic bones are undergoing transformation. The animal received 60,000 rat units of estrogen over a period of eighty days. The transplant was eighty days old.

distinct thickening and cellularity of the posterior ligament. It showed that active resorption of the interpubic cartilage had been proceeding at a rapid rate. The original, untransplanted segment of the pubic arch revealed active proliferation of the posterior ligament and resorption of the posterior cortices. In another animal, which had received 60,000 rat units of estrogen, examination of the transplanted pubic arch eighty days after the implantation revealed definite hypercellularity of the ligaments and resorption of the posterior cortices (fig. 7). Much more active transformation had occurred, however, in the untransplanted segment.

Here the interpubic cartilage was undergoing cystic degeneration in some places and, in addition, was being resorbed by the highly cellular ligaments.

SUMMARY AND CONCLUSIONS

This study represents an experimental investigation of the effects of estrogen on castrated male animals, particularly on their skeletons. The subjects were male guinea pigs weighing about 400 Gm. each. Of the 12 animals, 8 were given injections of estrogen, and in 4 of these 8 transplantation of part of the pubic symphysis was performed. Four additional guinea pigs served as controls. The duration of the experiments was twenty-eight to eighty days, and the total amount of estrogen administered was 12,000 to 60,000 rat units.

The experiments show, first, that castrated male guinea pigs can be successfully feminized by injections of estrogen, the feminization being revealed in enlargement of the nipples and the formation of areolas. As to the skeleton, no striking alterations were observed in the capsules of the major joints, in the epiphysial plates, in the costochondral junctions, in the symphysis menti or in the sacroiliac articulations. It was in the region of the symphysis pubis that the estrogen exerted its striking effect. The ligaments, especially the posterior ones, became hypercellular, increased in thickness and invaded the interpubic cartilages and the posterior cortices of the pubic bones. In some instances the interpubic cartilages underwent secondary degenerative changes resulting in the appearance of slits. Even in transplanted segments of the pubic arch the posterior ligaments became hypercellular when the animals received sufficient quantities of estrogen. In the animals which did not receive estrogen the posterior ligaments of transplants of pubic bone underwent little or no change. Apparently the pubic ligaments, especially the posterior one, are affected in a specific way by estrogen. The interpubic cartilage partakes in the changes, but its reaction seems to be influenced to a great extent by that of the pubic ligaments. The lack of reaction in the ligaments of the sacroiliac joint is striking.

RESPIRATORY PHYSIOLOGIC PHENOMENA DURING INHALATION ANESTHESIA

EDWARD B. TUOHY, M.D.
ROCHESTER, MINN.

This paper concerns some of the important features of anesthesia induced by various gases from the standpoint of preoperative medication, physiologic phenomena associated with administration of most inhalation anesthetic agents and supportive measures for the patient during anesthesia.

In order to allay fear and promote rest, it is customary to administer a sedative agent to most patients before the operation. Usually morphine sulfate is administered, because it promotes rest and diminishes the patient's perception of pain. Although as a rule opium derivatives do not produce sleep unless given in large doses, they do enhance the effect of most soporific drugs, such as bromides and barbiturates. For this reason it is common practice to use such agents as pentobarbital sodium, sodium amytal and various other barbiturates and bromide preparations in conjunction with opiates. The different drugs of the atropine series, such as belladonna, atropine sulfate and scopolamine, are used routinely to inhibit secretion of mucus during inhalation anesthesia, to inhibit parasympathetic (vagus nerve) activity and to antagonize the metabolic depressant action of morphine.

The dose of any drug, especially when used for premedication purposes, should be sufficient to produce a safe pharmacologic effect. I do not believe that it is possible to state a specific dose for every patient. As the basal metabolic rates of patients vary widely, it is important to bear in mind that the different drugs vary diversely in the intensity of their action. In other words, whereas for one person a given dose of morphine sulfate or of a barbiturate is insufficient to produce a pharmacologic effect, for another person the same quantity of the same agent constitutes an overdose. It is suggested, therefore, that a more accurate method for administering premedication agents be employed. To certain patients one should administer small doses of the drug preoperatively and repeat them whenever necessary to produce the desired effect. Furthermore, one should not begin administration of an inhalation anesthetic in most instances until a reasonable time has been allowed for the agents given orally and hypodermically to produce their optimal effect.

From the Section on Anesthesia, the Mayo Clinic.

The mechanism of inhalation anesthesia is complex and depends on many factors. Some of the most important of these are the physical laws which determine diffusion of gas and vapors and the anatomic, physiologic and chemical considerations incident to respiration. During induction of anesthesia with an inhalation anesthetic the concentration, or partial pressure, of any given anesthetic agent is higher in the alveolar air than is the partial pressure of the agent in the blood and tissue. The rate of diffusion of the anesthetic into the blood stream is rapid at first, depending, of course, somewhat on the area of alveolar membrane exposed to the gas and the rapidity of pulmonary circulation. As the concentration of the anesthetic rises in the blood, the rate of its diffusion from the alveoli decreases, and an equilibrium is established between the partial pressure of the gas in the alveoli and that in the blood. When anesthesia is discontinued, a reverse process occurs, and at first there is rapid elimination of the anesthetic agent from the blood and the tissues into the alveoli of the lung. Gradually this is followed by slower elimination, as the concentration of the agent increases in the alveolar spaces. The importance of hyperventilation of the lungs with oxygen and then air at the termination of the period of administration of an anesthetic is apparent when one considers the mechanism of the diffusion of gases.

One must keep this physiologic process in mind when administering an inhalation anesthetic, because there are many factors which influence the diffusion of gas and vapors into the blood stream. The ultimate aim in administration of any anesthetic, especially an inhalation anesthetic, is the introduction of the agent into the tissues via the blood stream with the least possible disturbance to normal physiologic processes. Obstruction of the air passages or depression of breathing to such an extent that an adequate exchange of gases in the lungs is not possible definitely curtails the success of the anesthetic procedure. The difficulties most frequently encountered in relation to the maintenance of proper passage of air are those in which stridor (laryngeal spasm) occurs and those in which the tongue falls back against the posterior wall of the pharynx and obstructs the airway. The latter situation usually can be remedied by use of a mouth airway, a pharyngeal tube or an intratracheal tube. Stridor may occur as a result of administering an anesthetic agent too rapidly, and in such a case the stridor is usually due to the irritating action of the anesthetic on the vocal cords. Also, it may be attributable to indirect stimulation of other tissues, for example, traction on the pelvic and abdominal viscera.

The treatment of stridor due to too concentrated mixtures of anesthetic agents is usually simple and is accomplished by diluting the anesthetic vapor with oxygen. If stridor occurs when traction is made on viscera the situation is frequently more difficult to correct, and it is

usually embarrassing to the anesthetist. When visceral traction is made, laryngeal spasm may be produced in a patient under relatively deep as well as in one under light surgical anesthesia, and it seems that the most effective remedy is intratracheal intubation. Occasionally an increase in bag pressure helps to reduce the stridor and decrease the noise incident to vibration of the vocal cords. The difficulties encountered with this procedure are the possibility of distending the stomach with gas and the fact that the procedure is tedious and wasteful of gases. When an inhalation anesthetic is administered to a young child by the closed method (so-called carbon dioxide absorption method) one should employ a type of gas machine and carbon dioxide absorber unit which will require the least expenditure of respiratory effort on the part of the child. The "to and fro" type of apparatus, with an absorber placed between a face mask and a breathing bag, probably requires less effort than the gas machines using so-called circle breathing units.

In the absence of respiratory obstruction there are certain other factors which influence physiologically the activity of respiration. These are chiefly of two types: chemical agents and afferent nerve impulses. Concerning the chemical stimuli of respiration, it is generally accepted that any increase in hydrogen ion concentration of the cell bodies of the formatio reticularis in the medulla enables these cells to emit more potent efferent nerve impulses. Although any acid, such as lactic acid, may increase the hydrogen ion concentration within these cells in the medulla and thus stimulate respiration under certain conditions, carbon dioxide has a specific affinity for these cells of the respiratory center, and any change in the p_H of blood effected by carbon dioxide seems to produce a greater respiratory response than an equivalent change produced by some other acid, such as lactic acid. A normal respiratory center is extremely sensitive to carbon dioxide, and the usual response of the center to carbon dioxide and oxygen is definite stimulation of respiration.

In the presence of narcosis and anoxemia with a diminished oxygen supply to the brain and medulla, the addition of carbon dioxide may cause a momentary stimulation of respiration. At the same time, however, it increases the demand of the center for oxygen, which is at a low level even prior to stimulation with carbon dioxide. The result is momentary respiratory stimulation followed suddenly by hypopnea and apnea. The only treatment for such a condition is administration of sufficient oxygen to rejuvenate the medullary center of the brain. If the cells of the respiratory center are severely depressed, either from narcosis or from anoxemia, and have lost all their power of reacting to carbon dioxide, the addition of this agent may cause a further narcotic action, and respiration may cease after one or two breaths.

It is recognized also that anoxemia stimulates respiration, but its action is due to the production of certain afferent impulses with resultant reflexes around certain nerve receptors in the region of the carotid sinus and the ascending aorta. The general belief at present is not that anoxemia produces a direct stimulating effect on the respiratory center but rather that lack of oxygen in the cells of the respiratory center is a definite depressant.

The stimulus effected by anoxemia from the receptor in the region of the carotid sinus which causes hyperpnea is not mechanical as are the stimuli of some of the reflexes originating in this region which play a part in the control of pulse rate and blood pressure; rather it is a chemical stimulus. According to several investigators,[1] this reflex, originating from the carotid receptor in response to the stimuli of anoxemia, is more resistant than the reflex originating in the respiratory center to the deleterious effects of anesthetic agents, narcotic drugs, anoxemia and excessive concentration of carbon dioxide. Reflex stimulation of respiration by anoxemia must not be allowed to be present for any length of time, because irreparable damage may be done to the body tissues, especially those of the brain. Oxygen should be administered to abolish the anoxemia. Frequently, however, when oxygen is administered while respiration is being reflexly motivated by anoxemia, apnea or hypopnea will result, and clinically the picture is comparable to that observed when carbon dioxide has been administered. However, in spite of the apnea which may result, one must elect to remove the anoxemia and must not be misguided because respiration may have stopped momentarily. With the aid of artificial respiration plus oxygen, regular breathing usually will be resumed within a few minutes.

There is another neurogenic reflex which originates in the lungs, often referred to as the Hering-Breuer reflex, which regulates the rate and depth of inspiration by means of nerve impulses traversing the vagus nerve. This reflex is a check valve to limit inspiration or expiration and initiate a reflex either to distend or to deflate the lungs rhythmically. From a practical standpoint this reflex is most valuable when irritating vapors, such as those of ether, chloroform or divinyl ether, are employed in gaseous mixtures. As the concentration of ether is built up in the blood, the cells of the respiratory center become more narcotized, and it has been shown that the neurons responsible for initiation of expiratory efforts become depressed more quickly than do those associated with inspiratory activity. This is important because inspiratory movements of the chest disappear soon after expiratory

1. Schmidt, C. F.: Recent Studies on Some Physiological Phenomena Related to Anesthesia, Anesth. & Analg. **17**:24-34 (Jan.-Feb.) 1938.

efforts are lost, and it is at this point that dangerous levels of anesthesia are reached and anoxemia ensues.

It should be clear that the respiratory signs of anesthesia are tremendously important and deserve as much consideration as any one physical sign that may be demonstrated during inhalation anesthesia. Except in certain circumstances, vasomotor and cardiovascular aberrations usually occur simultaneously with respiratory changes or inadequacies, and one should be alert to detect depressions in blood pressure, alterations in pulse rate and other signs of impending shock.

In the event of respiratory and circulatory depression during inhalation anesthesia, one should discontinue administration of anesthetics and ventilate the patient's lungs with oxygen, either by manual compression with the use of the breathing bag or by means of slight puncture pressure with the aid of an intratracheal tube. The practice of simultaneously administering fluids intravenously when the systolic blood pressure is falling is almost unquestioned. Such an agent as saline solution, dextrose and saline solution, solution of acacia or whole blood should be used.

In many cases of impending shock, before capillary paralysis has occurred one finds a marked degree of vasoconstriction, because the vasomotor center is still active, at least for a time, until anoxemia supervenes and depresses the center. It is not wise to administer a vasoconstrictor agent, such as epinephrine, when the blood vessels are already markedly constricted. It is much more advantageous to restore the circulatory blood volume by means of intravenous administration of fluids, preferably blood, in order to insure a medium on which the heart can work. The opportune moment for the use of vasomotor agents occurs when the systolic blood pressure has not fallen to low levels, that is, not below 70 or 80 mm. of mercury. When vasoconstrictors are administered sufficiently early the vasomotor tone and the systolic pressure can be maintained for a reasonable time, at least long enough to permit relatively simple venipuncture.

There are many factors other than the anesthetic itself which influence or hasten so-called surgical shock, some of which are hemorrhage, loss of heat, sweating, trauma to tissues and duration of the surgical procedure. All these conditions should be considered during administration of the anesthetic, and it is advisable to synchronize the depth of anesthesia and specific supportive measures as far as possible with the physical status of the patient at varying intervals during the operation.

INTRA-ABDOMINAL PRESSURE

A CRITICAL REVIEW AND AN EXPERIMENTAL STUDY

CONRAD R. LAM, M.D.
DETROIT

Previous writers [1] have commented on the confusion which exists on the subject of intra-abdominal pressure. The recent literature regarding this is small, but one finds many conflicting statements. Some writers state flatly that the intra-abdominal pressure is negative; others, that it is positive, atmospheric or variable. I cannot agree with the assertion in a recent paper [2] that "Several facts have been well established in the literature. There is normally a sub-atmospheric pressure within the peritoneal cavity." The authors of this paper used "intraperitoneal" and "intra-abdominal" interchangeably. In succeeding paragraphs it will be shown that it is not "well established in the literature" that the intra-abdominal pressure is negative and also that careful distinction must be made between the terms just referred to. The discrepancies in the literature are due to confusion in the use of these terms and to faulty interpretation of experimental results. The situation was well described by Livingston,[1a] who stated: "Authors, in describing conditions which prevail within limited regions of the abdomen or which exist in prescribed circumstances, have at times so extended their statements and so generalized, that considerable confusion and conflicting data have accumulated."

Is intra-abdominal pressure of sufficient significance to warrant careful definition and study? Surgeons have given adequate attention to blood pressure, intrapleural pressure, intrathecal pressure and various intravisceral pressures. In contrast, there is generally a poor conception of intra-abdominal pressure, although this pressure is probably significant in a fair number of conditions encountered clinically. For example,

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From the Division of General Surgery, the Henry Ford Hospital.

1. (*a*) Livingston, E. M.: A Clinical Study of the Abdominal Cavity and Peritoneum, Am. J. Surg. **8**:1110, 1930. (*b*) Hitzenberger, K.: Zwerchfell und intraperitonealear Druck, Klin. Wchnschr. **8**:961 (May 21) 1929. (*c*) Wildegans, H.: Ueber den intraperitonealen Druck, Mitt. a. d. Grenzgeb. d. Med. u. Chir. **37**:308, 1924.

2. Beecher, H. K.; Bradshaw, H. H., and Lindskog, G.: Effect of Laparotomy and Distention on Lung Volume, J. Thoracic Surg. **2**:444 (June) 1933.

Brunn and Brill [3] suggested that elevation of the diaphragm by postoperative distention might have an effect on pulmonary complications. Beecher, Bradshaw and Lindskog [2] found a decrease in pulmonary volume as a result of distention of the abdomen in experimental animals. Pneumoperitoneum is being used in selected cases of pulmonary tuberculosis as an adjunct to other forms of collapse therapy.[4] Hernia, postoperative wound separation, ascites, ovarian cysts and parturition involve consideration of intra-abdominal pressure. These few examples are cited to justify this attempt to present an adequate conception of intra-abdominal pressure.

As has been stated, the terms intra-abdominal and intraperitoneal must be carefully distinguished in connection with this subject. Intra-abdominal pressure is a hydrostatic type of pressure, the result of the fact that the abdominal organs and other structures are contained in a vessel, the abdominal cavity. I accept Livingston's definition of "abdominal cavity": "The abdominal cavity is a term synonymous with the word abdomen. Within the cavity are situated all of the abdominal organs, namely, most of the alimentary canal, the digestive glands, kidneys, ureters, part of the bladder, peritoneum, blood vessels, nerves and certain fetal remnants." Except for the pelvic outlet, the abdominal cavity is a space enclosed by structures resistant to pressure, namely, bones, muscles and fascia. The retroperitoneal structures are affected by changes in abdominal tension as much as are the so-called intraperitoneal structures. For example, urine may flow from the ureteral orifices in spurts synchronous with the respiratory fluctuations in intra-abdominal pressure. Since pressures are freely transmitted from the abdomen to the true pelvis, the latter will be considered as an extension of the former, and most general statements regarding pressure apply to both cavities.

To clarify my conception of intra-abdominal, intraperitoneal and intravisceral pressures, a mechanical model of the abdomen was constructed, a cross section of which is shown in figure 1. Coils of thin rubber tubing (surgical drains) were placed inside a "peritoneal cavity" which consisted of a bag of transparent rubber sheeting. A small hydrostatic bag (*A*) was inserted between the "intestines" and the

3. Brunn, H., and Brill, S.: Postoperative Atelectasis: Factors in Etiology, Prevention and Treatment, Tr. Am. S. A. **48**:53, 1930.

4. Banyai, A. L.: Observations on the Radiological Chest Volume During Artificial Pneumoperitoneum Treatment, Radiology **31**:48 (July) 1938. Trimble, H. G.: Pneumoperitoneum in the Treatment of Pulmonary Tuberculosis, Dis. of Chest **4**:18 (June) 1938. Hobby, A. W.: Pneumoperitoneum, an Adjunct to the Treatment of Pulmonary Tuberculosis, ibid. **4**:18 (Sept.) 1938. Stokes, J. B.: Pneumoperitoneum for Pulmonary Compression, Illinois M. J. **73**:137 (Feb.) 1938.

"abdominal wall." The coils of tubing (*B*) were inflated with a bulb. The pressures in spaces *A*, *B* and *C* were recorded on a kymographic drum.

At the start of the experiment, the "intestines" were in a flattened condition, and the excess air in the peritoneal space was removed, it being borne in mind that the true peritoneal space is only a potential one. The coils of tubing were then inflated until a high "intravisceral" pressure was obtained. This procedure caused the bag which measured intra-abdominal pressure to indicate an increase, but the pressure in the intra-

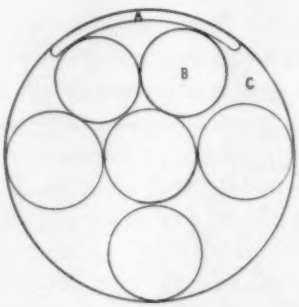

Fig. 1.—Diagram of a mechanical model of the abdomen. *A*, intra-abdominal pressure; *B*, intravisceral pressure; *C*, intraperitoneal pressure.

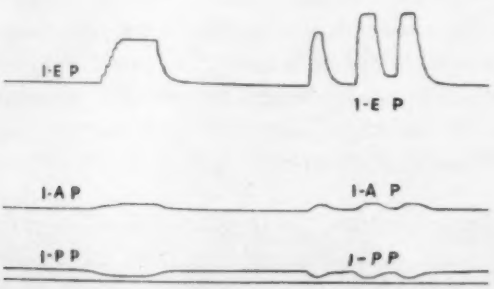

Fig. 2.—Kymographic record of pressures in the mechanical model. *I-E P*, intraenteric (intravisceral) pressure; *I-A P*, intra-abdominal pressure; *I-P P*, intraperitoneal pressure.

peritoneal space showed no increase; on the contrary, there was a paradoxic fall. This was obviously due to the fact that in the change of the "intestines" from the flattened condition to the distended, cylindric condition there was an increase in the potential intraperitoneal space, and a negative pressure was created. A record of the paradoxic behavior of the "intraperitoneal" pressure is shown in figure 2.

In the review of the literature which follows it will be seen that the investigators fall into two classes: (1) those who tried to determine

intra-abdominal pressure (*A*, fig. 1) by measuring intravisceral pressure (*B*), and (*2*) those who measured intraperitoneal pressure (*C*).

1. In this class are those who placed bags in the stomach, urinary bladder, rectum and uterus. Obviously, it is impossible to eliminate entirely the intrinsic pressure of the viscus due to the tonicity or contractions of its walls. Certain of the results would appear to be valid, and these instances will be mentioned in the review which follows.

2. In this class are those who made manometric measurements of the intraperitoneal pressure by placing needles or trocars in the peritoneal space. This method is subject to the following limitations: If positive pressure exists, it is not reflected by the manometer because of the lack of a medium to transmit the pressure. If atmospheric pressure exists, it cannot be distinguished from positive pressure. If negative pressure exists, this is correctly registered on the manometer. However, as was demonstrated with the mechanical model, it is theoretically possible to obtain negative intraperitoneal pressure in the presence of positive intra-abdominal pressure.

For a review of the literature up to 1911, dependence has been placed on the extensive bibliography of Emerson.[5] He cited 4 authors who stated that the intra-abdominal pressure is atmospheric, 6 who stated that it is negative, 12 who stated that it is positive and 5 who stated that it is variable. The paper of Emerson and subsequent papers will be reviewed briefly.

Emerson did 24 experiments, inserting a trocar attached to a water manometer into the peritoneal cavities of various experimental animals. He concluded that the normal intra-abdominal pressure is slightly positive. His twenty-fifth and last experiment was as follows: a laparotomy was done on a dog under water, an inverted bell jar filled with water being held over the operative site to catch any bubbles of gas which might escape from the peritoneal cavity. No bubbles escaped, and he rightly concluded that there is normally no gas in the peritoneal cavity. However, his last experiment casts doubt on the interpretation of the results obtained in the previous 24, because in the absence of a gaseous medium to flow out of the manometer system the positive pressure readings must have been artefacts.

The work of Keppich[6] (1921) is often cited. This author cautioned against confusion of intra-abdominal and intravisceral pressures, but he used the terms intraperitoneal and intra-abdominal interchangeably. He put a fenestrated needle in the peritoneal cavities of dogs and human

5. Emerson, H.: Intra-Abdominal Pressures, Arch. Int. Med. **7**:755 (June) 1911.

6. Keppich, J.: Ueber den intraperitonealen Druck, Arch. f. klin. Chir. **116**: 276 (July 30) 1921.

beings. He concluded that the normal intraperitoneal pressure in man is —0.5 to —3.4 cm. of water. He noted that manual compression of the abdomen, coughing and changes of position did not alter the pressure. His results gave no information about intra-abdominal pressure, for the reasons stated.

The next paper is that of Wildegans [1c] (1924). He inserted a needle in the peritoneal cavities of 60 patients. In 19 of these the puncture was in the epigastrium, and in 41 it was in the hypochondrium. In 56 instances there was no fluctuation of the manometer. In 3 there was a positive reading, and in these there was gas or fluid in the peritoneal space (bullet wound, perforated ulcer and ascites). In 1 instance a negative pressure was registered, but only during inspiratory dyspnea while an anesthetic was being given. Wildegans then attempted to measure the intra-abdominal pressure by measuring the force required to introduce air into the peritoneal cavity. By this method he found a positive pressure of 4 cm. of water in rabbits and pressures of 1.5 to 12 cm. in 46 human beings. The subjects were all in the horizontal position, and the punctures were made near the umbilicus.

The other author who is often cited in support of the statement that the intra-abdominal pressure is negative is Wagoner.[7] Monkeys, rabbits, cats and dogs were placed in the supine position, and a needle connected with a manometer was thrust into the peritoneal cavity. Slightly negative pressures were encountered, which fluctuated with respiration. Normal values for monkeys were said to be —0.2 to —0.4 cm.; for rabbits, —3.0 to —5.5 cm.; for cats, —0.8 to —1.4 cm. and for dogs, —2.0 to —4.4 cm. Fifty cadavers were tested, and an average value of —5 cm. was obtained. Positive pressures were obtained in 9 cases, associated with distention, obesity or ascites. It is unnecessary to point out again the shortcomings of this method of determining intra-abdominal pressure.

Overholt [8] recognized the fact that the peritoneal cavity is a cleft, empty except for a thin coating of fluid. However, he accepted the work of Keppich and that of Wagoner and, looking for a negative pressure, inserted cannulas into the peritoneal cavity in the region of the epigastrium and measured the intraperitoneal pressure with the closed manometer of Lewis. A mean subatmospheric pressure was recorded for 32 dogs, and 1 animal showed an atmospheric pressure. The values ranged from —0.5 to —10 cm. A shift to the vertical position with the head up caused a marked fall in the pressure in the upper part of the abdomen and an increase in pressure in the lower part.

7. Wagoner, G. W.: Studies on Intra-Abdominal Pressure, Am. J. M. Sc. **171**:697 (May) 1926.

8. Overholt, R. H.: Intra-Peritoneal Pressure, Arch. Surg. **22**:691 (May) 1931.

Murphy and Mengert [9] placed a balloon in the vagina and, checking the position roentgenographically, found that the top of the balloon was out of the true pelvis. They tested the effect of visceral weight and found that it varied from atmospheric with the subject in the knee-chest position to 31.2 cm. of water with the subject in the sitting position. They found that voluntary straining produced the maximum effect in the sitting position, a pressure of 200 cm. of water being obtained.

Salkin [10] repeated some of the work of Wagoner with similar results. Kountz, Gottlieb and King [11] placed a bag in the stomach of a dog. They obtained values ranging from atmospheric to —4 cm. of water. With cough, the pressure went up to 40 cm. of water.

It is seen that in the previous experimental work attempts have been made to measure intra-abdominal pressure (*A*, fig. 1) by measuring *B* or *C*. The question which presents itself is, Why not measure *A* directly? A small bag placed in the abdominal cavity could be used to measure the effective intra-abdominal pressure at any given point in the abdomen. There are two objections. First, the hermetic conditions of the peritoneal cavity have been disturbed by the operation of inserting the bag, and air has been permitted to enter. Second, a foreign body has been introduced. The first objection can be partly disposed of by assuming that the air introduced at laparotomy may be largely removed by subsequent needle aspiration and that what remains may be absorbed shortly. The second objection is valid, and it can only be stated that the pressure determinations in the experiments to be described are for recently laparotomized dogs with a small foreign body left in the abdominal cavity.

EXPERIMENTAL METHOD AND RESULTS

The intra-abdominal pressure in dogs was measured by inserting a small rubber bag (glove finger) in various parts of the abdominal cavity. The bag was connected to a water manometer by means of a small rigid rubber tube (no. 10 catheter). The bag held about 7 cc. of air without the development of intrinsic pressure. When a determination of pressure was to be made, the bag was emptied by suction and partially inflated with 4 cc. of air, after which connection with the manometer was made. Thus, both positive and negative pressures were indicated. The intra-abdominal pressure was varied by inflation of the alimentary tract

9. Murphy, D. P., and Mengert, W. F.: Intra-Abdominal Pressures Created by Voluntary Muscular Effort: I. Technique of Measurement by Vaginal Balloon, Surg., Gynec. & Obst. **57**:487 (Oct.) 1933. Mengert, W. F., and Murphy, D. P.: Intra-Abdominal Pressures Created by Muscular Effort: II. Relation to Posture in Labor, ibid. **57**:745 (Dec.) 1933.

10. Salkin, D.: Intra-Abdominal Pressure and Its Regulation, Am. Rev. Tuberc. **30**:436 (Oct.) 1934.

11. Kountz, W. B.; Gottlieb, L., and King, R.: The Influence of Changes of Abdominal Tension upon Pulmonary Function, J. Clin. Investigation **15**:601 (Nov.) 1936.

with air, by creation of a tension pneumoperitoneum and by changing the position of the animal. The intraperitoneal pressure was frequently measured by thrusting a large needle into the peritoneal cavity, to demonstrate the futility of this method of determining intra-abdominal pressure.

EXPERIMENT 1 (to determine the effect of distention of the alimentary tract on intra-abdominal and intraperitoneal pressure).—On March 10, 1939, an experiment was performed on a bitch weighing 10 Kg. with the animal supine; the intraperitoneal pressure was atmospheric in both hypochondriac regions. The intrapleural pressure was —1 to —5 cm. of water. The animal was anesthetized with 6 cc. of dial administered intraperitoneally. A short incision was made in the midline above the umbilicus. The lower part of the colon was ligated, and a hydrostatic bag was inserted in the epigastric region. The incision was closed, and the air in the peritoneal cavity was removed by aspiration. A cannula was

TABLE 1.—*Results of Experiment 1*

Intravisceral Pressure, Cm. of Water		Intra-Abdominal Pressure, Cm. of Water	Intraperitoneal Pressure
Before inflation		10	0 (atmospheric)
During inflation	13	11	0
	26	23	0
	40	30	0

TABLE 2.—*Results of Experiment 2*

Intraperitoneal Pressure (Tension Pneumoperitoneum), Cm. of Water	Intra-Abdominal Pressure, Cm. of Water
0	4
4	11
10	14
15	16.5
20	20
0	4.5

inserted in the esophagus for subsequent inflation of the alimentary tract. The results in this experiment are shown in table 1.

EXPERIMENT 2 (to determine the effect of tension pneumoperitoneum on intra-abdominal pressure).—The air in the alimentary tract of the same animal was removed, and various degrees of tension pneumoperitoneum were created (table 2).

Experiment 1 showed that moderate distention did not produce a significant rise in the intra-abdominal pressure, but higher intravisceral pressure (up to 40 cm. of water) caused an increase. The insertion of a needle into the intraperitoneal space gave no indication of the elevated intra-abdominal pressure. The experiment with tension pneumoperitoneum showed that the pressure of the air was added to that due to the weight of the viscera until a pressure of 20 cm. water was reached, after which the intraperitoneal and intra-abdominal pressures were identical.

EXPERIMENT 3 (to determine the abdominal pressure in various parts of the abdomen and the effect of change of posture).—On April 10, 1939, a dog weighing 10 Kg. was anesthesized with 6 cc. of dial given intraperitoneally. The intrapleural pressure was —1 to —10 cm. of water. The intraperitoneal pressure in the

epigastrium with the animal supine was —0.5 cm of water. With the animal erect, the intraperitoneal pressure under the diaphragm fluctuated between —4 and —6 cm. An incision was made in the midline above the umbilicus. One pressure bag was sutured to the central tendon of diaphragm, and another was attached to the anterior abdominal wall, just above the bladder. The pressures on the two bags

TABLE 3.—*Results of Experiment 3*

Position of Animal	Intra-Abdominal Pressure, Cm. of Water		
	Under Diaphragm		In Lower Part of Abdomen
	On Inspiration	On Expiration	
Supine	3.0	3.5	5.5
Erect	— 3.5	— 3.0	10.0
Head down	11.0	16.0	0.5
Head up (45 degrees)	— 2.5	— 2.0	8.0
Head down (45 degrees)	6.0	5.5	2.0
Supine (second reading)	3.0	3.5	5.5

TABLE 4.—*Results of an Additional Experiment* *

Position of Animal	Intra-Abdominal Pressure, Cm. of Water		
	Under Diaphragm		In Lower Part of Abdomen
	On Inspiration	On Expiration	
Supine	8.0	9.0	9.0
Head up	2.0	5.0	12.0
Head down	17.0	19.0	2.0

* May 5, 1939. The animal was a bitch weighing 6 Kg. Ether anesthesia was used. The subject had recovered from the anesthesia when the readings were made.

TABLE 5.—*Result of a Second Additional Experiment* *

Position of Animal	Intra-Abdominal Pressure, Cm. of Water		
	Under Diaphragm		In Lower Part of Abdomen
	On Inspiration	On Expiration	
Supine	1.0	—4.0	4
Head up	—5.0	—2.0	6-10 (Insp., Exp.)
Head down	10.5	7.5	0.5

* May 8, 1939. The animal was a bitch weighing 6.5 Kg. Ether anesthesia was used, and narcosis was obtained with ½ grain (0.03 Gm.) of morphine.

with the animal in various positions were noted (table 3). (Similar experiments were performed on 5 additional animals, the results in 2 other typical experiments being recorded in tables 4 and 5.)

COMMENT

In these experiments an attempt has been made to demonstrate that abdominal pressure is a function of the hydrostatic pressure of the viscera and the relation of the volume of the abdominal cavity to the

volume of its contents. Increase in the volume of the alimentary canal by distention makes the abdominal contents relatively large for the abdominal cavity, and increase in pressure results. In this connection it should be mentioned that considerable increase in the volume of the abdominal contents is tolerated before tension develops, because of reflex relaxation of the abdominal wall as demonstrated by Coombes.[12] Spasm of the abdominal muscles or voluntary straining for any reason tends to decrease the size of the abdominal cavity and thus to raise the pressure. When the animals were held in an upright position, a negative pressure was usually found under the diaphragm, but in the case of 1 animal (table 4), which had recovered from the anesthetic and was straining, a positive pressure was maintained.

It is evident that concise statements may be made about abdominal pressure if such statements are qualified by naming the exact region of the abdomen under consideration and the posture of the body. For example, the statement "The intra-abdominal pressure was positive" is meaningless, while the statement "With the subject standing, the intra-abdominal pressure at the left internal abdominal ring was 25 cm. of water" is significant.

In this study no direct measurements of the intra-abdominal pressure in man have been made. On the basis of these animal experiments and the work of others [9] on man it is probable that in an adult subject in the standing position there is a pressure of 25 to 40 cm. of water in the lower part of the abdomen and in the pelvis. If the abdominal muscles are under tension, higher values are reached. This pressure decreases as the upper part of the abdomen is approached, until under the dome of the diaphragm there may be a negative pressure. This is variable, depending on the tonicity of the abdominal wall, and it shows respiratory fluctuation. Some observers [13] have noted pressures in this locality identical with the intrapleural pressure.

If the subject is standing on his head, the pressure relations are reversed, a positive pressure being against the diaphragm and a negative pressure in the pelvis. This is illustrated by the ballooning of the rectum and bladder when the subject is in the knee-chest position.

SUMMARY

1. The literature on the subject of intra-abdominal pressure is reviewed, and the reasons for many conflicting opinions are indicated.

12. Coombes, H. C.: The Mechanism of Regulation of Intra-Abdominal Pressure, Am. J. Physiol. **61**:159 (June) 1922.

13. Hamilton, C. E., and Amazon, P.: Accidental Pneumoperitoneum in Artificial Pneumothorax Therapy, Am. Rev. Tuberc. **34**:160 (Oct.) 1936.

2. A plea is made for exact terminology in statements regarding intra-abdominal pressure. The importance of distinguishing between intra-peritoneal, intravisceral and intra-abdominal pressures is emphasized. Statements should be qualified by mentioning the exact region of the abdomen under consideration and also the posture of the body.

3. Experiments are described in which the intra-abdominal pressure in various regions of the dog's abdomen under different conditions was determined by the use of a small hydrostatic bag.

4. Statements are made regarding the probable pressure relations in the human abdomen.

THE APPENDICAL STUMP

ITS MANNER OF HEALING IN THE OPEN AND IN THE CLOSED METHOD OF TREATMENT

ISIDOR KROSS, M.D.

Attending Surgeon, City Hospital; Associate Surgeon, Beth Israel Hospital and Montefiore Hospital for Chronic Diseases

NEW YORK

The technic of operations in all fields of surgery has been standardized on physiologic principles so that, while the detailed procedure itself may and does vary with different surgeons, the underlying principle on which the procedure is based is the same. There is, however, an outstanding exception, and that applies to treatment of the stump of the appendix. While methods of handling the stump are fairly numerous, they may all be grouped into two categories: (1) the buried stump method and (2) the nonburied stump method.

Frequently the reasons brought forward by the proponents of one method in justification of their procedure are the very ones that are used by the opponents of that same method in justification of the other. For instance, Torek [1] pointed to the danger of postoperative adhesions and intestinal obstruction in cases in which simple ligation or the unburied stump method was used and cited evidence to prove that this danger is real. In 1 instance a typical picture of acute intestinal obstruction occurred six weeks after an appendectomy performed by the simple ligation method. The patient died without being operated on, and at autopsy the stump of the appendix was seen to be adherent to the parietal peritoneum, with a loop of intestine caught and obstructed beneath it. In a second case cited by Torek the patient was operated on for acute ileus that occurred after a similar operation, and the findings were the same.

Hortolomei,[2] on the other hand, reported the cases of 2 patients who had been operated on by the buried stump method and in whom acute intestinal obstruction did occur postoperatively. In both patients adhesions were found at the site of the appendical stump. This author maintained that the buried stump causes formation of an abscess, which

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From the Pathologic Laboratory of the Beth Israel Hospital, Dr. I. Plaut, Director.

Read before the Surgical Section of the New York Academy of Medicine on April 7, 1939.

1. Torek, F.: Zentralbl. f. Chir. **59**:204, 1932.
2. Hortolomei, N.: Zentralbl. f. Chir. **58**:2379, 1931.

may rupture either into the intestinal lumen or within the general peritoneal cavity, in the second instance causing general peritonitis. He cited the history of such a case, in which the appendical stump was buried and the patient had some pain in the right lower quadrant of the abdomen on the fourth postoperative day. At reoperation peritonitis was found, originating from a ruptured abscess that had formed at the site of the appendical stump. Hortolomei performed "simple ligation appendectomy" on 621 patients without any accidents (except for 1 death from embolism on the eighth postoperative day), and in 13 of these whose condition subsequently required a second laparotomy he found a total absence of adhesions. He cited de Martel, who reported 3 cases of generalized peritonitis following treatment by the buried stump method as a result of perforation of the cecal wall by the purse string suture. De Martel [3] reported the findings in 61 cases in which a second laparotomy was performed on patients who had been operated on for appendicitis by the open method. In none of these did he find any evidence of postoperative adhesions. Hilarowicz [4] reported a case of appendicitis in which simple ligation was employed in the treatment of the stump and in which peritonitis set in on the third and the patient died on the fifth postoperative day. Autopsy showed generalized peritonitis, with the appendical stump completely patent.

Roeder [5] reported his findings in 105 laparotomies performed on appendectomized patients. In 98 cases he found adhesions. In 8 cases he considered these of no significance. In the remaining 90, however, he considered them "of a type (1) to cause an interference with the peristalsis of the caecum, (2) to cause localized pain and tenderness, and (3) to be looked on as a potential point of small bowel obstruction." This author maintained that "the two most overlooked factors in the etiology of crippling post-operative adhesions are the purse-string inverting suture and the neglected stump of the meso-appendix" and that "the most frequent source of infection is the suture used to invert the stump of the appendix."

Maloney,[6] in a report of 3,500 cases in which the simple ligation method was used and the stump left unburied, stated that he encountered no postoperative ileus and that in the cases in which subsequent reoperation was done adhesions were never found. Riedel [7] stated significantly:

> I consider the suturing of a peritoneal cuff over the appendix stump as a very dangerous procedure. As regards going so far as to bury the infected stump into the caecal wall, this must absolutely lead to perforation into the lumen of

3. de Martel, F.: Bull. et mém. Soc. de chir. de Paris **46**:1438, 1920.
4. Hilarowicz, H.: Zentralbl. f. Chir. **59**:2407, 1932.
5. Roeder, C. A.: Appendectomy: A Study in Technic, Arch. Surg. **11**:18 (July) 1925.
6. Maloney, F. F.: Ann. Surg. **82**:260, 1925.
7. Riedel, G.: Zentralbl. f. Chir. **30**:1393, 1903.

the caecum. If the inverting sutures hold and adhesions are strong enough, *we will not fear an intraperitoneal rupture,* but need only consider the disadvantages resulting from an ulcer in the caecum as a result of the intracaecal rupture.

Mayo,[8] in a publication entitled "Appendicitis," stated:

There are four reasons why I do not invert the carbolized stump of the appendix: (1) Dr. Robertson of the Section on Pathologic Anatomy at the Clinic has found that invariably, in cases in which appendectomy with inversion of the stump has been done in combination with some other surgical procedure and death has resulted, there is a pus pocket in the inverted stump up to twenty-one days postoperatively; (2) the cultured suture material used to invert the stump, once having run through the intestinal wall, invariably is infected with pathogenic bacteria; (3) noninversion shortens the surgical procedure, and (4) I have not had occasion to regret not having inverted the stump.

Hermann [9] reported a case in which operation was done by the buried stump method and in which five days after the operation an abscess formed within the cecal wall, perforated into the peritoneal cavity and caused death. Bürkle-de le Camp,[10] from Lexer's clinic, reported the end results in 3,200 cases of acute and chronic appendicitis treated by inversion of the open stump. He claimed to have avoided necrosis, abscess formation, fecal fistula and hemorrhage. Fowler,[11] however, called attention to the danger of secondary hemorrhage from an artery that is found fairly frequently running longitudinally within the wall of the appendix. Seelig [12] called attention to this same complication, which was described to him in a communication from Dr. Charles Elsberg and Dr. Charles Mayo. Lilienthal [13] thirty-six years ago strongly advocated simple ligation as the safest and most effective method and noted an entire absence of adhesions in all cases in which he performed a laparotomy on an appendectomized patient.

In spite of all the evidence favoring the open method, the closed, or buried stump, method still is used most extensively. With such strongly divided and antithetic opinions regarding the proper method of treating the appendical stump, it seemed to me worth while to determine what actually happens in the experimental animal when the stump is treated by the open method in one series of animals and by the closed method in a second series.

MATERIAL AND METHOD

The adult rabbit was used in these experiments. In all there were 23 experiments with the buried stump method and 16 with simple ligation. About 3 to 4

8. Mayo, C. W.: Southwest Med. **18**:397, 1934.
9. Hermann, F.: Zentralbl. f. Chir. **28**:1028, 1901.
10. Bürkle-de le Camp, H.: Zentralbl. f. Chir. **59**:2082, 1932.
11. Fowler, H.: Am. J. M. Sc. **113**:152, 1897.
12. Seelig, M. G.: Ann. Surg. **40**:710, 1904.
13. Lilienthal, H.: M. News **83**:1020, 1903.

inches (7.5 to 10 cm.) of the appendix was amputated after simple ligation of the appendix proper. In one series of animals the stump was inverted and buried. In the other series the stump was dropped, untreated, into the free peritoneal cavity. At varying intervals after operation the animal was anesthetized and the appendical stump first examined in situ and then removed for microscopic examination. In the first 8 experiments to be reported in detail, the stump was treated by simple ligation; in the remainder, it was inverted and buried.

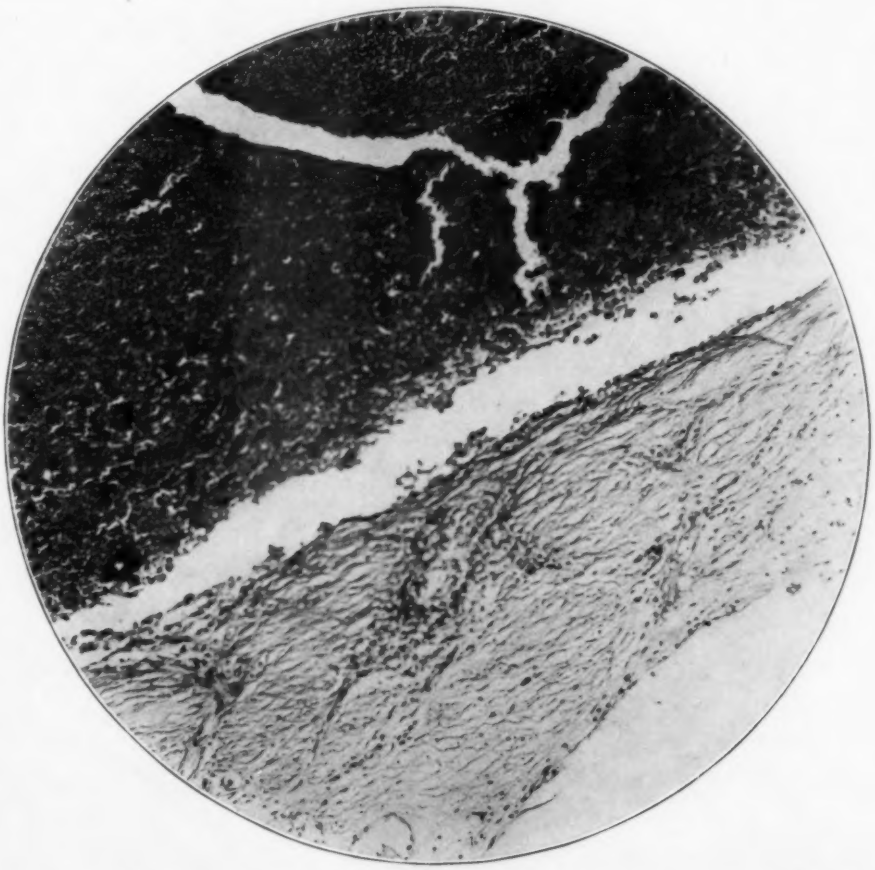

Fig 1 (rabbit 3).—Section of an appendical stump treated by simple ligation. The photomicrograph was taken fourteen days after the operation.

PROTOCOLS

RABBIT 1 (examined at three months).—There was no evidence of any appendical stump. The intestine was adherent to the former site of the stump.

RABBIT 2 (examined at ninety-two days).—The stump of the appendix was free. The surface was smooth internally and externally. Microscopic examination showed the mucosal layer to be continuous. The muscle layer was united by young connective tissue with numerous mitotic figures.

RABBIT 3 (examined at fourteen days).—The stump appeared as a gray-white globular mass covered with a thin, glistening membrane. Microscopic examination showed complete reproduction of the blind extremity with its mucosa. The stump proper was surrounded by young connective tissue and was completely necrotic.

RABBIT 4 (examined at nine days).—Omentum completely surrounded the stump. Microscopic examination showed the stump completely necrotic and surrounded by young connective tissue which separated it from the distal portion of the cecum.

Fig. 2 (rabbit 9).—Section of a buried appendical stump. The photomicrograph was taken one day after the operation.

RABBIT 5 (examined at five days).—The stump was covered with omentum. The blind extremity was reformed. Young connective tissue could be seen uniting the muscle tissue. The stump proper was completely necrotic; there was aseptic necrosis in different stages. The necrotic stump was completely surrounded by new connective tissue.

RABBIT 6 (examined at fifty days).—The stump consisted of a small piece of an ovoid mass completely covered with glistening peritoneum. The mucosal lining of the appendix proper was normal throughout.

RABBIT 7 (examined at three days).—The stump was small, grayish white and sharply demarcated. There was massive necrosis of the stump.

RABBIT 8 (examined at twenty-nine days).—There was a small white appendical stump. There was no sign of inflammation. The mucous membrane layer of the blind extremity was continuous throughout.

RABBIT 9.—On Sept. 17, 1934, the appendix was ligated and amputated 4 inches (10 cm.) from the tip with a catgut ligature. The stump was inverted with a

Fig. 3 (rabbit 9).—Another section of the same buried stump.

silk purse string suture. On the next day (September 18) the animal was killed. The appendical stump was adherent to a loop of small intestine. About 1/16 inch (0.16 cm.) from the site of adhesion there was seen a horizontal red-blue streak 1/16 inch (0.16 cm.) wide and 3/8 inch (1.1 cm.) long. On inversion of the stump there was noted on the mucosal surface at the tip an area about 1/16 inch (0.16 cm.) in diameter, gray and sharply outlined. Microscopic examination revealed a marked inflammatory reaction within the tissues of the buried stump and necrosis involving the distal mucosa, with ulceration into the free lumen of the cecum. The tissues at this site showed hemorrhagic infiltration.

RABBIT 10.—On Sept. 28, 1934, the appendix was ligated and amputated about 3 inches (7.5 cm.) from the tip. The stump was inverted with a silk purse string suture. On October 3 the animal was killed. The stump of the appendix was firmly adherent to two loops of small intestine. The lymph nodes in the mesentery were enlarged and soft. On inversion of the appendical stump, the mucosa of the distal pole was seen; it was brown and sharply limited from the surrounding normal-appearing mucosa. When part of this discolored tissue was teased out, it proved to be necrotic. This area was about ½ inch (1.3 cm.) in diameter. Microscopic examination revealed typical necrotic changes in the discolored area. The mucosa at this site was completely ulcerated, giving the necrotic tissue direct approach to the lumen of the intestine. The surrounding tissue contained hemorrhagic infiltration.

RABBIT 11.—On Sept. 7, 1934, the appendix was ligated and amputated about 2 inches (5 cm.) from the tip with catgut. The stump was inverted with a silk purse string suture.

On September 12 the animal was killed. The stump of the appendix was adherent to the lateral wall of the ascending colon. About ¼ inch (0.6 cm.)

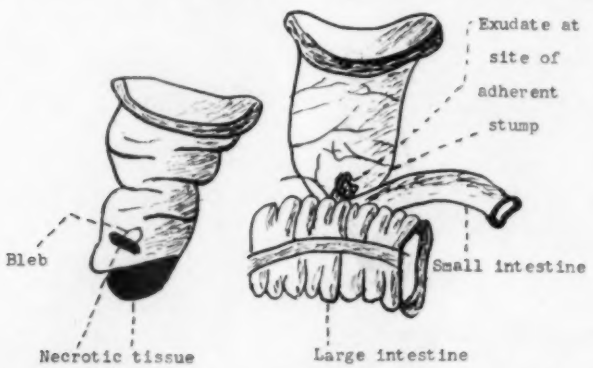

Fig. 4 (rabbit 11).—Inverted appendical stump five days after the operation.

from the purse string suture there was an irregular patch of gray-white exudate. Behind the colon there was seen a loop of small intestine adherent to the stump. These three structures were excised en masse.

When the appendical stump was inverted and turned inside out it was clearly seen that the lowermost portion consisted of a brown structure about ½ inch (1.3 cm.) in diameter; it was sharply delimited from the rest of the specimen, which was perfectly normal in appearance. A similar brown area about ⅛ inch (0.3 cm.) in diameter was seen to be separated from the first brown area by a zone of healthy mucosa ¼ inch (0.6 cm.) wide. Part of this second discolored area was loosened from the underlying tissue, which consisted of a superficial yellow-based ulcer. The mucous membrane over the discolored area on microscopic examination showed complete necrosis of tissue, vacuolation, pyknosis and shadow cell formation. The immediately adjacent tissue showed a marked inflammatory reaction. The rest of the mucosa was normal in appearance.

RABBIT 12.—On Oct. 8, 1934, the appendix was ligated and amputated about 3½ inches (8.8 cm.) from the tip. The stump was inverted with a silk purse string suture. On October 15 the animal was killed. The appendical stump was adherent to the small bowel. The mesenteric glands were enlarged and soft. On

inversion of the appendical stump a circular area at the extreme tip, about 1 cm. in diameter, was seen sharply delimited from the surrounding normal-appearing mucosa. This area was dark brown. At one portion of this area a piece of the silk purse string suture could be seen.

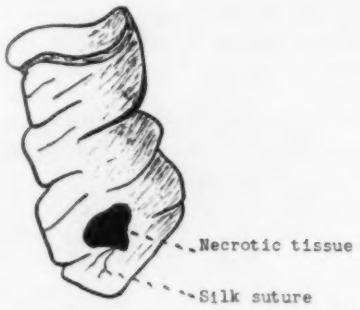

Fig. 5 (rabbit 12).—Inverted appendical stump seven days after the operation.

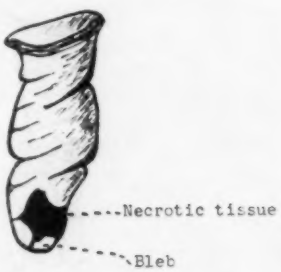

Fig. 6 (rabbit 13).—Inverted appendical stump four days after the operation.

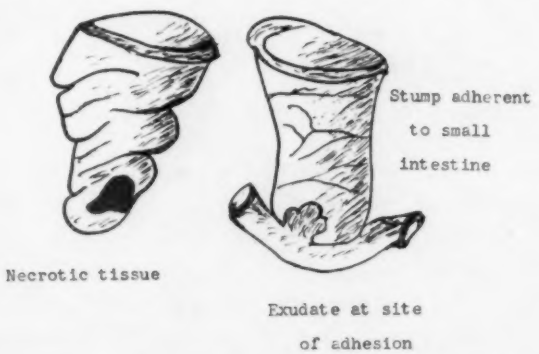

Fig. 7 (rabbit 14).—Inverted appendical stump nine days after the operation.

Microscopic examination disclosed complete necrosis of the discolored area. The soft tissues surrounding it presented marked hemorrhagic infiltration, and the mucosa overlying the necrotic area was ulcerated, yielding direct access of the necrotic tissue to the lumen of the intestine.

RABBIT 13.—On Sept. 14, 1934, the appendix was ligated and amputated 4 inches (10.1 cm.) from the tip. The stump was inverted with a silk purse string suture. On September 18 the animal was killed. The appendical stump was adherent to the small intestine. (The appendix and the adherent portions of small intestine had been removed en masse for microscopic examination.) The mesenteric glands were soft and enlarged. The inverted appendical stump presented an irregularly circular area about ½ inch (1.2 cm.) in diameter, sharply limited

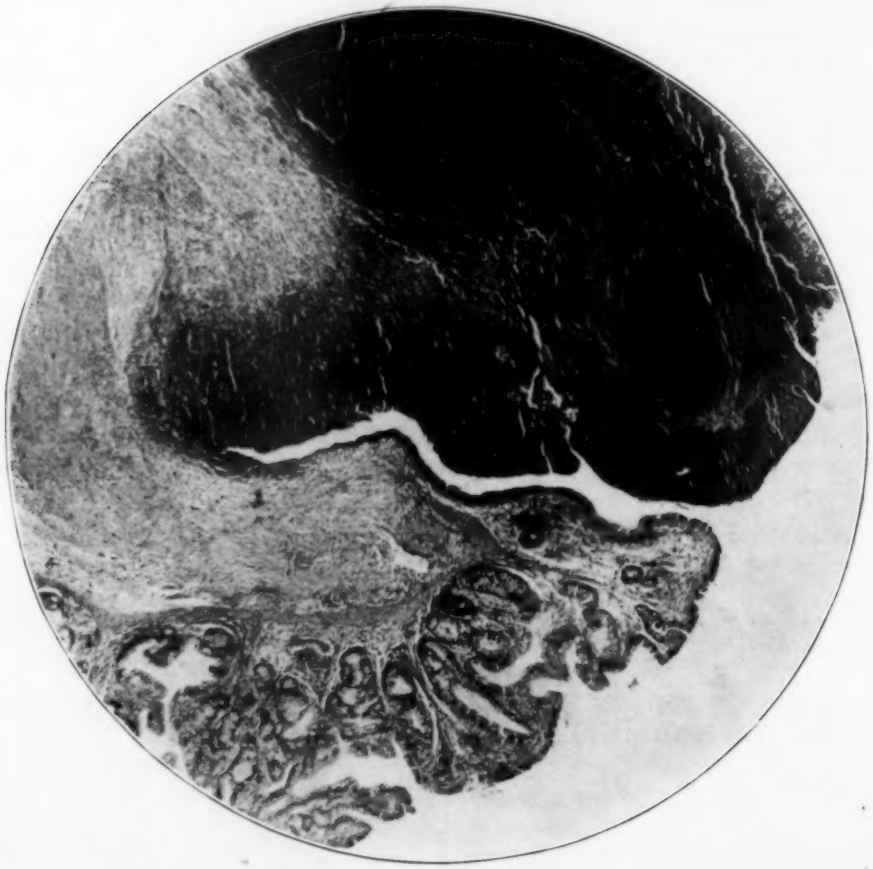

Fig. 8 (rabbit 14).—Section of a buried appendical stump. The photomicrograph was taken nine days after the operation.

and gray-brown, situated near the distal blind extremity. Immediately distal and adjacent to the brown area were two small blebs about 1/16 inch (0.16 cm.) in diameter. The mucosa of the ulcerated areas on microscopic examination showed complete necrosis, with direct access to the lumen of cecum. The adjacent mucosa showed a marked inflammatory reaction, with a submucous hemorrhagic infiltration.

RABBIT 14.—On Sept. 12, 1934, the appendix was ligated and amputated about 2 inches (5 cm.) from the distal extremity with catgut. The stump was inverted with a silk purse string suture. On September 21 the animal was killed. The stump

of the appendix was found adherent to the small intestine. The silk suture was partly buried beneath the adhesion. A group of coalescent gray-white areas about ½ inch (1.3 cm.) in diameter could be seen at this adherent zone. These areas were subperitoneal and slightly elevated. The mesenteric glands were soft and large. The inverted specimen showed two discrete oval ulcerations filled with gray-brown substance which in one of the ulcers had a frayed-out appearance. These areas were 1/16 to ⅛ inch (0.16 to 0.3 cm.) in diameter. The rest of the mucosa was normal in appearance. Microscopic examination revealed that the mucosa corresponding with the two ulcerated areas was completely necrotic and afforded direct access to the lumen of the cecum. The immediately adjacent areas were markedly inflamed and hemorrhagic. The rest of the mucosa was normal in appearance.

COMMENT

One of the most striking features noted in the study of the section from the buried stump was the combination of hemorrhagic infiltration and ulceration of the mucous membrane of the cecal wall distal to the insertion of the purse string suture. In spite of the fact that during the insertion of the suture no visible injury to the blood vessels and no visible hematoma was noted, the microscopic picture of hemorrhagic infiltration was a constant phenomenon. These changes could be readily seen with the naked eye in the mucous membrane of the inverted specimen. Microscopic examination shows clearly that these changes consist of hemorrhagic infiltration with ulceration of the mucosa. In contrast to this picture, examination of the unburied stump treated by simple ligation showed an absence of these features in every specimen examined. This experimental evidence bears out the clinical observation of Colp,[14] who called attention to the danger of injury to the blood vessels during insertion of the inverting purse string suture.

Another interesting feature noted macroscopically was the frequent marked enlargement of the mesenteric lymph nodes in the experiments in which the stump was buried and the absence of this change when the stump was left unburied. This affords experimental confirmation of the clinical findings of Mayo, those of Riedel and those of de Martel, who observed and reported the presence of intense inflammation and changes in the cecal wall surrounding the buried stump. In several animals (rabbits 9, 11 and 14) pinhead-sized cecal abscesses were noted. In none of the experiments in which the stump was left unburied was any abscess formation observed. Adhesions were present in all of the experiments but were much more extensive in the experiments in which the stump was buried.

Distal to the ligature the stump proper showed massive necrosis in all instances. In the cases in which simple ligation was done there was

14. Colp, R.: Ann. Surg. **84**:837, 1926.

an abrupt change at the site of the ligature. The tissue distal to the ligature showed massive necrosis. The tissue proximal to it was normal in appearance. In the cases in which the stump was buried, however, there were hemorrhagic infiltration and necrosis with ulceration of the mucous membrane in part of the cecal wall, between the purse string suture and the appendical ligature.

The stump in the cases in which it was left unburied was invariably covered by omentum or mesentery, and on microscopic examination newly formed connective tissue could be seen surrounding the entire stump distal to the ligature, completely separating it from all the surrounding viscera.

SUMMARY

In summarizing the salient features of the microscopic appearance of the specimen of buried appendical stump, the following observations may be noted.

The stump of the appendix is converted into massively necrotic substance. The cecal wall between the appendical ligature and the purse string suture in most parts appears perfectly normal but in some parts shows marked hemorrhagic infiltration separating the mucous membrane from the underlying tissue. In still other areas there is a complete loss of mucosa, with direct communication between the necrotic tissue of the stump and the lumen of the cecum. The picture is clearly that of a hemorrhagic infarct. In brief, the outstanding features are massive necrosis, hemorrhagic infiltration and ulceration of the mucous membrane, with direct communication between the lumen of the bowel and the necrotic contents of the buried stump.

In the stump treated by simple ligation the picture is different. There is no evidence of any hemorrhagic infarct. The stump itself undergoes necrosis and is completely separated from the rest of the cecum at the site of the ligature.

A definite zone of fibrous tissue forms around the stump, isolating it completely.

The process of healing in the buried stump is accompanied by marked adhesions between the stump and the surrounding tissue, marked lymphadenitis, occasional pericecal abscess formation, hemorrhagic infarction of the cecal wall between the appendical ligature and the purse string suture, ulceration of the mucous membrane in the area of infarction and massive necrosis of the stump.

In the ligated stump the healing process is accompanied by adhesions between the appendical stump and the surrounding tissue (less marked, however, than those found in the buried stump), necrosis of the stump

and formation of a definite zone of fibrous connective tissue around the stump. There is no hemorrhagic infarct, no lymphadenitis and no destruction of tissue proximal to the appendical ligature. These findings point clearly and definitely to the ordinary ligature (without inversion) method as the simplest, safest and most effective procedure in the treatment of the appendical stump.

After this paper had been completed, there was published by Ochsner and Lilly [15] a method which it is claimed does away with all the dangers of a ligated buried stump and of postoperative hemorrhage. A purse string suture is passed in such a manner that the artery in the wall of the long axis of the stump is caught and the open stump of the appendix is inverted into the lumen of the cecum.

15. Ochsner, A., and Lilly, G.: Surgery **2**:532, 1937.

TRANSPLANTED EPIPHYSIAL CARTILAGE

J. DEWEY BISGARD, M.D.
OMAHA

In experimental animals long bones have been lengthened abnormally by increment from epiphysial cartilages transplanted to their shafts from neighboring bones. The grafts in these experiments were total massive segments, thick layers of adjacent bone from the epiphyses and diaphyses being included with the cartilage. Clinical application of the procedure has been precluded by the magnitude of the operation and the uncertainty of results.

In the experiments described here the possibility of lengthening bone by a less formidable procedure was investigated. All attempts, however, were unsuccessful.

EXPERIMENTS

In each of 8 goats approximately 1 month old two segments of the epiphysial cartilage plate with the adjacent layers of bone were removed from opposite sides of the femur and transplanted to the shaft of the tibia. The two segments of cartilage removed constituted less than half the plate, the central portion being left undisturbed. These segments were inserted between the two portions of the tibia, which had been divided transversely with resection of a complete segment of the shaft, equal in thickness to the graft to be interposed. The severed end of each portion was marked with a steel shot placed in a drill hole in the cortex. In all the animals the periosteum between the two portions was resected, and in 4 an additional cuff of periosteum 0.5 to 1 cm. wide was removed. This was done in the hope of preventing the formation of a bridge of subperiosteal bone which would unite and lock the severed ends, thus preventing their distraction by bone laid down by the intervening growth cartilage. The legs were immobilized in plaster casts without padding. One animal lost its leg as a result of gangrene from circulatory interference. One had an infected wound with loss of the graft.

In the remaining 6 goats union was sufficiently firm in three weeks to permit removal of the casts. The animals were then observed for three months, and during this period there was considerable growth. During the first three weeks the distance between the shot was slightly diminished, but from that time on it remained unchanged. Thus, not only was there failure of the transplanted growth cartilage to contribute growth in length of the bone but a minute amount of shortening developed, presumably from absorption either of the cut ends or of the graft itself. One definite reason for this failure of the epiphysial cartilages to function is apparent in the roentgenograms taken three weeks after operation (figs. 1 *B* and 2 *B*). In this short interval arching struts of newly formed bone

From the Departments of Surgery and Physiology, the University of Nebraska College of Medicine.

had bridged the defect and united the two parts of the tibia around the periphery. This occurred despite the fact that the periosteum was resected and even after approximately 1 cm. of the cut ends of the tibia had been denuded of periosteum. Although the presence of the cartilage definitely delayed central repair of the defect, it was gradually replaced by bone. At postmortem examination, three months after operation, no cartilage was found in 2 animals and only small scattered remnants in 4.

SUMMARY

After transplantation of segments of epiphysial cartilage from the femur to the site of bisection of the shaft of the tibia, all growth in

Fig. 1.—Bisected tibia with a full thickness segment of epiphysial cartilage interposed between the parts. The intervening periosteum was removed. The cut ends of the tibia were marked with steel shot placed in drill holes in the cortex. *A*, roentgenogram taken immediately after operation; *B*, roentgenogram taken three weeks after operation; *C*, roentgenogram taken three months after operation. Note the extent of repair in three weeks, the progressive replacement of transplanted epiphysial cartilage by bone and the progressive lengthening of the bone. Note the slight shortening which took place during the first three weeks and that thereafter the shot remained equidistant. None of the growth in length, therefore, was acquired at the site of section from either the transplanted growth cartilage or the process of repair of the bisection. All growth took place at the epiphysial ends of the shaft, the major portion at the proximal end.

the length of the tibia took place at the epiphysial ends. There was no interstitial growth. In no instance was length gained at the site of bisection. Soon after operation the distance between the shot used as markers became slightly less. Thus there was preliminary shortening from absorption either of bone at the severed ends of the tibia or of cartilage of the graft. Subsequently the shot remained equidistant.

Slight separation of the parts of the tibia and resection of the intervening periosteum did not prevent union, nor did absence of periosteum from the severed ends. It must be remembered, however, that the animals used (goats) were very young and, like all newborn animals, had tremendous propensity for repair and growth.

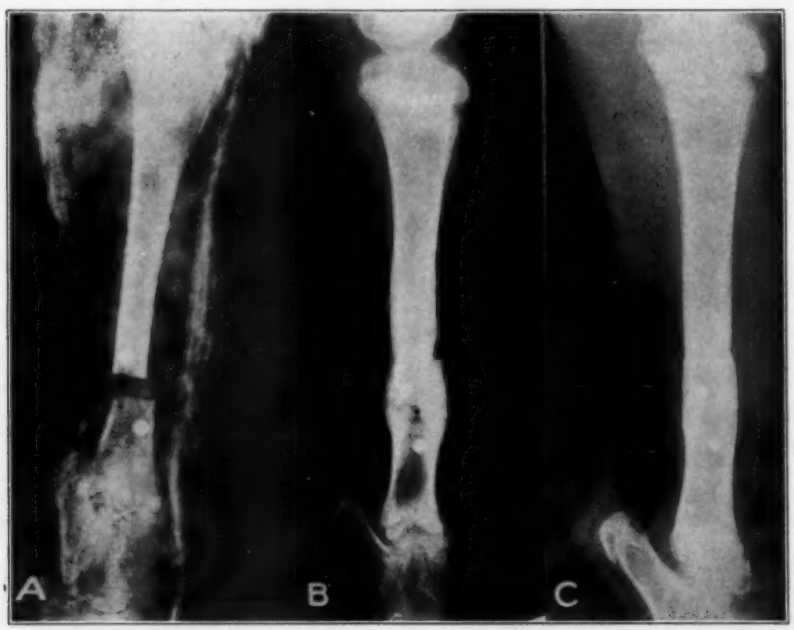

Fig. 2.—Bisected tibia treated like that in figure 1 except that the periosteum was resected from the ends of the parts for a distance of approximately 1 cm. The roentgenograms were taken (*A*) one day, (*B*) three weeks and (*C*) three months after operation. In the absence of periosteum, union by bridging struts of new bone took place rapidly but less profusely than in the animal represented in figure 1. Similarly, the shot remained equidistant after a slight preliminary shortening of the intervening distance during the first three weeks. Thus all growth in length was acquired from the epiphysial cartilages at the ends of the bone.

Full thickness segments of the epiphysial cartilage interposed in the tibial shafts failed to contribute length. Literally, these grafts were imprisoned and unable to give increment had this function otherwise been preserved.

INTUSSUSCEPTION DUE TO HEMANGIOMA OF THE JEJUNUM

FREDERICK T. MERCHANT, M.D.
MONTREAL, CANADA

There has always been considerable interest in benign tumors of the small intestine because of their extraordinary infrequency and the serious or even fatal complications which may be associated with them. Kassemeyer [1] in 1912 was able to collect 78 cases of benign tumor of the small bowel from a total of 284 cases of benign tumor of the gastrointestinal tract as a whole. King [2] in 1917 reviewed the literature and reported 50 cases of benign tumor of the small intestine. Raiford [3] in 1932 collected 50 cases in a study of 11,500 autopsies and 45,000 surgical specimens at the Johns Hopkins Hospital. Rankin and Newell [4] in 1933 were able to find only 35 cases in the records of the Mayo Clinic. The cause of such tumors and the reasons for their infrequency have never been satisfactorily explained, although Raiford stated the belief that the unsusceptibility of the small intestine to tumor growth is associated with the embryologic, anatomic and physiologic peculiarities of this region. No age period is exempt, although benign tumors tend to occur more frequently in the earlier decades, while malignant tumors are characteristic of the later years.

In summarizing the records of the Royal Victoria Hospital and the Pathological Institute it was found that there were 6 benign tumors of the small intestine among 50,775 surgical specimens examined between the years 1915 and 1939. Eighteen cases were observed in 7,340 autopsies performed from Jan. 1, 1915 to May 1, 1939. Histologic examination of these 24 tumors resulted in the following diagnoses: lipoma, 6; fibroma, 4; adenoma, 3; adenomatous papilloma, 3; hemangioma, 3; carcinoid, 2; fibroadenoma, 1; fibromyxoma, 1, and

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From the Department of Pathology, Pathological Institute, McGill University, and the Royal Victoria Hospital.

1. Kassemeyer, E.: Tumorinvagination des Darms, Deutsche Ztschr. f. Chir. **118**:205, 1912.

2. King, E. L.: Benign Tumors of the Intestine with Special Reference to Fibroma, Surg., Gynec. & Obst. **25**:54, 1917.

3. Raiford, T. S.: Tumors of the Small Intestine, Arch. Surg. **25**:122 (July); 321 (Aug.) 1932.

4. Rankin, F. W., and Newell, C. E.: Benign Tumors of the Small Intestine, Surg., Gynec. & Obst. **57**:501, 1933.

lymphoma, 1. Secondary growths, cysts, embryonic rests and the like were excluded. Three glandular polyps (non-neoplastic) were omitted. The 24 tumors were located in the small bowel as follows: duodenum, 6; jejunum, 6, and ileum, 12. Intussusception was reported in 7 cases, or 29 per cent.

It was observed, however, that the incidence of benign tumors of the small intestine in no way indicated the frequency with which these tumors were encountered in the gastrointestinal tract as a whole (from cardia to anus). During the same period (1915 to 1939), a total of 274 benign tumors of the entire gastrointestinal tract were collected. Of these tumors, 174 were obtained from the surgical specimens and 100 from the postmortem material. The tumors were located in the digestive tract as follows: stomach, 43; small bowel, 24; cecum, 13; colon, 31; sigmoid flexure of colon, 19; rectum, 114, and anus, 30. Again, questionable or secondary tumors, embryonic rests and growths showing probable early malignant changes were not included. The incidence of benign tumors of the small intestine was, therefore, 8.7 per cent of all such neoplasms in the tract, while that of hemangiomas in the same region was 1.09 per cent.

Of the benign tumors of the small bowel reported, those of vascular origin are among the most rare. It is interesting to observe that Gascoyen [5] is given credit for reporting the first case of hemangioma of the bowel. In the series of cases noted, King [2] found, 1; Raiford,[3] 3, and Rankin and Newell,[4] 2, and I found 3, 2 of which are reported here. Brown [6] in 1924 reviewed the literature and collected 20 cases of vascular tumor of the intestine. He found no relation between the sex and age of the patient and the number of tumors present. McClure and Ellis [7] in 1930 collected 25 cases, many of which were listed in Brown's group, and found the ages of the patients to range from 2 months to 79 years. Recently, Ackerman [8] has added 2 cases of cavernous hemangioma of the small intestine and 1 case in which tumors occurred in both the small and the large intestine. In general, the hemangiomas were of two types: the capillary type, with an abundant overgrowth of small blood vessels which may appear immature and angioblastic or mature with smooth muscle and fibrous tissue and the

5. Gascoyen: Case of Naevus Involving the Parotid Gland, and Causing Death from Suffocation: Naevi of the Viscera, Tr. Path. Soc. London **11**:267, 1860.

6. Brown, A. J.: Vascular Tumors of the Intestine, Surg., Gynec. & Obst. **39**:191, 1924.

7. McClure, R. D., and Ellis, S. W.: Hemangiomata of the Intestinal Tract, Am. J. Surg. **10**:241, 1930.

8. Ackerman, L. V.: Cavernous Hemangiomata of the Small and Large Bowel, Am. J. Cancer **30**:753, 1937.

cavernous type, with large, dilated blood-filled cavities, usually having a single endothelial cell lining with or without a smooth muscle wall.

These tumors in the intestine have been further classified by Brown into the following groups: 1. Multiple tumors of vascular arcades forming nodules in the submucosa and associated with the arteries or veins. They form vascular nevi or cavernous hemangiomas. 2. Submucosal tumors which grow toward the lumen of the intestine and may become ulcerated by pressure or trauma. 3. Submucosal tumors which may become polypoid in structure and grow to a size sufficient to obstruct the lumen or to bring about an intussusception. 4. Diffuse ringlike tumors which begin in the submucosa and involve the muscularis so that the lumen is constricted and an acute or chronic obstruction results. Malignant degeneration is occasionally reported (Winternitz and Boggs [9]).

The signs and symptoms of these vascular tumors are usually those of intestinal obstruction, hemorrhage or acute inflammation, although in about half the reported cases they were asymptomatic and were seen incidentally at operation or necropsy. The obstruction was attributable to encroachment on the lumen, to volvulus or to intussusception. Of these, intussusception was the least frequent.

Nicoll [10] in 1899 reported the first cases of intussusception at the site of a cavernous hemangioma. A survey of the literature over the last twenty years revealed only 2 other reported cases. McClure and Ellis observed 1 at operation in 1930; Weber [11] reported the last in 1936. Even at operation, however, one may fail to identify a vascular tumor as the cause of an intussusception, owing to the edema, infiltration and gangrene of the involved bowel or because of the gravity of the situation and the necessity for the surgeon to finish the abdominal procedure as quickly as possible. Although Raiford found intussusception to occur with 23 per cent of her series of benign tumors of the small bowel, it was not present in any of the patients with hemangioma. Rankin and Newell, with a general incidence of 17 per cent, found none in cases in which the tumors were vascular. Willis [12] collected 19 cases of intussusception due to adenoma from 7,492 autopsies at the Boston City

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9. Winternitz, M. C., and Boggs, T. R.: A Unique Coincidence of Multiple Subcutaneous Hemangio-Endothelioma, Multiple Lymphangio-Endothelioma of the Intestinal Tract and Multiple Polypi of the Stomach Undergoing Malignant Changes, Associated with Generalized Vascular Sclerosis and Cirrhosis of the Liver, Bull. Johns Hopkins Hosp. **21**:203, 1910.

10. Nicoll, J. H.: On the Removal of a Naevoid Tumor of the Intestine, Brit. M. J. **1**:843, 1899.

11. Weber, H.: Invaginatio ileocoecalis, bedingt durch ein Haemangioma simplex, Centralbl. f. allg. Path. u. path. Anat. **66**:33, 1936.

12. Willis, A. W.: Intussusception Resulting from Benign Tumors of the Intestine, Surg., Gynec. & Obst. **30**:603, 1921.

Hospital and the Massachusetts General Hospital, but in no instance was the condition due to hemangioma. Perrin and Lindsey [13] reviewed 400 cases of intussusception, Roan [14] 100, King [2] 18 and Winthrop [15] 18, but they cited no case of intussusception due to a vascular tumor. Biggs [16] discussed the problems of intussusception but failed to mention vascular tumors as an etiologic factor.

Recently I have had occasion to perform autopsy in 2 cases of intussusception due to hemangioma of the jejunum, and these are the only 2 cases on record at this institution of this type of intestinal obstruction caused by a benign vascular tumor of the small intestine. In 1 of them the condition was further complicated by hemangiomatosis involving the skin, stomach, kidney and adrenal gland. Because of this and the rarity of the condition, it was considered worth while to report these cases. In the only other case of hemangioma of the small bowel (jejunum) in the records of this institution the growth was found incidentally at autopsy. The tumor had caused no symptoms or complications, and hence the case will not be reported here in detail.

The diagnosis of vascular tumor of the bowel usually is obscure and is not made preoperatively, but the presence of such a tumor may be suspected on the basis of abdominal symptoms and the history or evidence of hemangiomas in other areas. According to Ackerman, a correct diagnosis should usually be made in "the presence of visible hemangiomata, obscure hemorrhage, and signs of acute or chronic obstruction, together with x-ray findings" suggestive of this condition (Judd and Rankin [17]).

REPORT OF CASES

CASE 1.—A. S., a 67 year old white woman, was admitted to the Royal Victoria Hospital on July 26, 1938, complaining of sudden onset of pain in the right lower quadrant of the abdomen, nausea and vomiting for two days and chronic constipation. There was no history of loss of weight, weakness or previous digestive distress. The family and functional histories were noncontributory. Physical examination showed the temperature to be 99.3 F.; the pulse rate was 96, and the respiratory rate, 20. The patient was emaciated, edentulous and dehydrated. There were no visible hemangiomas of the skin or mucous membranes. The lungs were clear. The heart was not enlarged, and the blood pressure was 128 systolic and 80 diastolic, but there were gallop rhythm and extrasystoles. There were splinting

13. Perrin, W. S., and Lindsey, E. C.: Intussusception: A Monograph Based on Four Hundred Cases, Brit. J. Surg. **9**:46, 1921.

14. Roan, O.: Intussusception Due to Benign Tumors of the Small Bowel, Texas State J. Med. **27**:782, 1932.

15. Winthrop, G. J.: Chronic Enteric Intussusception Due to Intestinal Tumors, J. A. M. A. **64**:1303 (April 17) 1915.

16. Biggs, M. H.: Intussusception of the Ileum in Adults Due to Benign Tumors, Surg., Gynec. & Obst. **33**:490, 1921.

17. Judd, E. S., and Rankin, F. W.: Hemangiomas of the Gastrointestinal Tract, Ann. Surg. **76**:28, 1922.

of the abdomen over the right side, tenderness beneath the right costal margin, enlargement of the liver and a palpable mass high in the right lower quadrant of the abdomen. The other systems were normal. The laboratory findings were as follows: leukocytes, 12,000 per cubic millimeter; urine, normal; stool, acholic and free of blood; value for nonprotein nitrogen, 23.5 mg. per hundred cubic centimeters; carbon dioxide-combining power, 49.3 mg. per hundred cubic centimeters; value for blood sugar (with the patient fasting), 75 mg. per hundred cubic centimeters. A diagnosis of acute appendicitis with abscess formation was made.

Course.—At operation, on July 27, an acutely inflamed, gangrenous ruptured gallbladder was found, with diffuse bile peritonitis. Cholecystotomy was done. The patient progressed fairly well, but on September 25 further exploration was necessary because of complete obstruction of the common bile duct. Convalescence was uneventful until September 29, when she suddenly went into shock and died.

Postmortem Examination.—There were no cutaneous lesions other than the healing McBurney incision and the 20 cm. recently closed right paramedian incision. There was evidence of diffuse peritonitis. The gallbladder was small, thick, black, lusterless and bound down by adhesions. The bile ducts and the ampulla of Vater were patent. There was no tumor in this region. The duodenum was filled with blood, as was the upper part of the jejunum to a point 40 cm. from Treitz's ligament. Here there was an intussusception measuring 20 cm. in length. At the distal end a round mass could be felt within the lumen, which on exposure was found to be a rounded polypoid tumor 3 cm. in diameter, with a broad base (fig. 1). The walls of the jejunum proximal to the intussusception and the duodenum were hemorrhagic.

Microscopic sections showed the tumor of the jejunum to consist of vascular channels of variable size, ranging from small capillary-like structures to large cavernous and cystic spaces. In some places the lining endothelium was composed of a single layer; in others it was piled up. The connective tissue stroma varied considerably in amount. The tumor evidently had arisen from the submucosal vascular plexus (fig. 2). The diagnosis was polypoid hemangioma. Sections of the jejunum revealed generalized congestion but no degeneration or necrosis of the tissue. Other sections showed exudative, necrotic cholecystitis, fibrosis of the ampulla of Vater, productive pleurisy, bronchopneumonia and adenoma of the thyroid.

Comment.—The diagnosis of intussusception due to hemangioma of the jejunum was made only at autopsy, as all the evidence indicates that the intussusception occurred shortly before death. It is well recognized (Rankin and Newell;[4] Biggs[16]) that the occasional intussusception encountered in the adult is most frequently caused by a neoplastic growth in the intestinal tract, in contradistinction to the spontaneous intussusception frequently encountered in children. In my opinion, the symptoms and signs of shock as noted in the history are explained by the occurrence of the intussusception and by the massive hemorrhage into the small bowel above the obstruction. The hemorrhage may have occurred from the vascular polyp, from the intestinal mucosa or from both; it was not possible to demonstrate conclusively which. It is interesting to observe that no other hemangiomas were found in the patient.

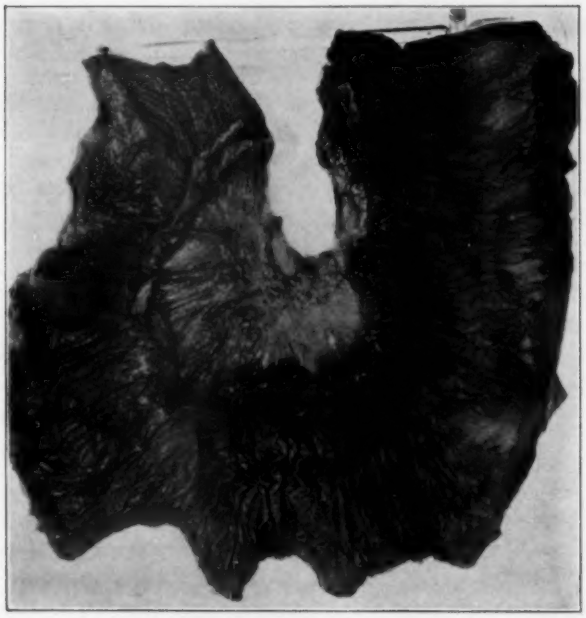

Fig. 1 (case 1).—Reduced intussusception. The jejunum is opened to demonstrate the polypoid hemangioma.

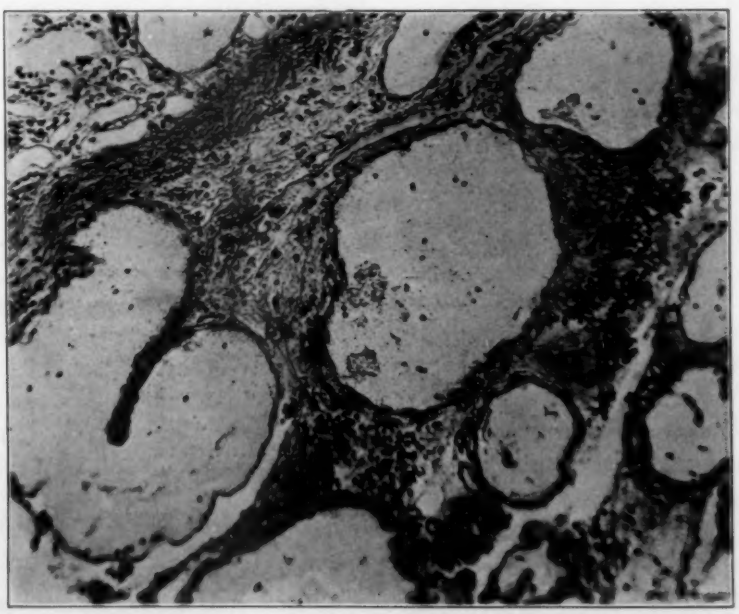

Fig. 2 (case 1).—Section of the polypoid hemangioma, showing the large blood-filled cavities; × 200.

CASE 2.—R. M., an 8 year old white boy, was admitted to the Royal Victoria Hospital on April 12, 1939, complaining of pallor and anorexia for three weeks and of sudden onset of crampy abdominal pain and vomiting twelve hours before, subsequent to a mild purge. This patient was first admitted to the hospital on Oct. 5, 1930, when only 3 days old, at which time the lower lip was found to be replaced by a large blue hemangioma measuring 2.5 by 1.5 by 1 cm. There were 19 other vascular tumors scattered over the scalp, body and extremities, varying from the size of a pinpoint to 1 cm. in diameter. The child had been otherwise normal at birth, and the family history was noncontributory. The hemangioma of the lip was excised and the diagnosis confirmed by pathologic study of the surgical specimen. The tumor recurred, however, when the patient was 3 months old, and since then there had been fourteen other admissions to the hospital, for excision or coagulation of the tumor or for plastic repair of the lip. These operations had been unsuccessful because of persistent recurrence of the tumor. Melena was never noted, although the records show rather constant hypochromic anemia throughout the eight years.

Physical examination on April 12 revealed a temperature of 99 F., a pulse rate of 136 and a respiratory rate of 30. The patient was extremely thin, pale, undernourished, restless and drowsy. There were numerous scars on the body and multiple hemangiomas over the trunk and extremities and beneath the nails. The lower lip was markedly deformed and largely replaced by scar tissue. No tumor was seen at this time. There was a soft, blowing, mitral systolic murmur and the blood pressure was 110 systolic and 80 diastolic. A mass was visible in the middle of the lower part of the abdomen, rising to the level of the umbilicus. It was about 8 cm. in diameter, doughy, irregular, dull to percussion, nonfluctuant and not movable on respiration. The mass itself was tender, but there was no generalized abdominal tenderness or rigidity. Peristalsis was not noted. Laboratory findings were as follows: white blood cell count, 19,000 per cubic millimeter; red blood cell count, 2,900,000 per cubic millimeter; hemoglobin, 35 per cent; stools, free of blood; urine, normal; nonprotein nitrogen content of blood, 21.4 mg. per hundred cubic centimeters; carbon dioxide–combining power, 42.5 mg. per hundred cubic centimeters; chloride content of the blood 323 mg.; and sugar content (with the patient fasting), 135 mg. per hundred cubic centimeters. Roentgenograms taken with and without contrasting mediums showed what appeared to be a soft tissue mass lying over the fourth or fifth lumbar vertebra on the right, with a slight amount of gas in the small bowel to the left but no evidence of intussusception. A tentative diagnosis of intestinal hemorrhage with obstruction due to volvulus, internal hernia or intussusception was made. Operation was delayed on the strength of the roentgenograms and because of the poor condition of the patient.

Course.—The following day the patient seemed to be improved, although the mass was still present. On April 14, however, he became worse, the pain and the pulse rate increased and the temperature rose to 101 F. A roentgenogram taken at this time showed marked distention of the small bowel on the right and suggested intestinal obstruction. Immediate exploratory operation was done with the patient under nitrogen monoxide–oxygen–ether anesthesia. An intussusception 30 cm. long was encountered at a distance of about 40 cm. from the ligament of Treitz. This was reduced with difficulty. Near the head of the intussusception a rather large tumor mass was found in the wall of the jejunum, which to external examination was thick and protruded into the lumen but was not polypoid. A small weakened area near the mesentery at one point was closed over with sutures. The bowel was believed to be viable. The abdomen was closed and drained with-

out further operative procedure because of the poor condition of the patient. Postoperatively the temperature rose to 106.3 F. and the pulse rate to 170; the abdomen became distended, and there were vomiting and a typical hippocratic facies. Continuous nasal suction and supportive treatment were given but produced no relief, and the boy died April 16, 1939.

Postmortem Examination.—There was marked deformity of the mouth, and the skin appeared thin and blue, but no tumor of the lip could be identified. There were innumerable hemangiomas on the body, as has been mentioned. In the upper part of the abdomen there was localized peritonitis. At a distance of 70 cm. from the ligament of Treitz the jejunum became greatly discolored and covered by exudate for about the same distance. About one third of the way from the beginning of this affected bowel there was a tumor-like mass 1.5 by 1.5 cm. in

Fig. 3 (case 2).—Portion of the jejunum containing the hemangioma, which has been exposed by cross section.

the wall. This seemed to be about 0.5 cm. in thickness (fig. 3) and resembled a hemangioma. Nearby, close to the mesentery, were two small perforations from which intestinal contents were pouring. Small hemangiomas were observed in the stomach, the left kidney and the left adrenal gland.

Microscopic sections showed the tumor mass to consist of cavernous communicating channels lined by rather dense fibrous tissue and devoid of fresh blood. A single endothelial cell lining was seen, but finer structures had been destroyed by the associated degenerative and necrotic enteritis in this section of the jejunum. A diagnosis of hemangioma with productive changes was made. Sections of the tumors of the stomach (fig. 4), skin, adrenal gland and kidney gave an essentially similar picture. These showed numerous distended large and small cavernous channels, all lined by a more or less single layer of endothelial cells. Special stains failed to show elastic tissue fibers but did show an occasional strand of

smooth muscle. Other sections showed confluent bronchopneumonia, catarrhal lymphadenitis and hyperplasia of the bone marrow. There was no intussusception at the time of autopsy.

Comment.—This case clearly indicates the serious and fatal complications which may arise from a benign hemangioma of the jejunum which has resulted in intussusception. The case illustrates most of the points outlined by Ackerman [8] for the diagnosis of intestinal obstruction due to vascular tumors. It is unfortunate that the intussusception had

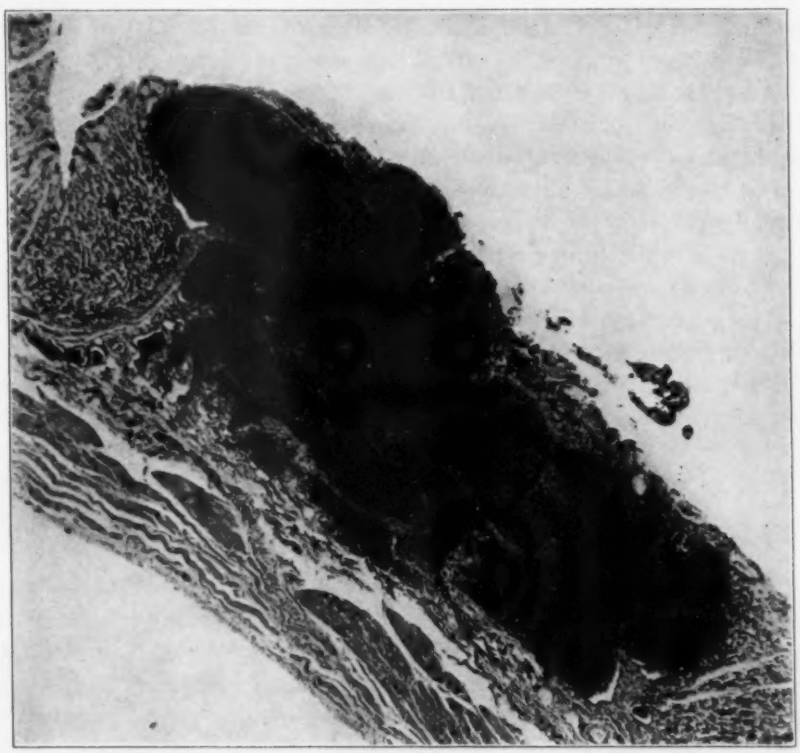

Fig. 4 (case 2).—Section of the submucosal hemangioma of the stomach, which is pushing outward into the cavity and has thinned the overlying mucosa; × 10.

continued until the bowel was gangrenous and perforation with fatal peritonitis had occurred. The multiplicity of the tumors and their marked tendency to recur, however, make it extremely unlikely that the prognosis could have been anything but poor.

It is interesting to observe that these 2 cases represent distinctly different age periods, one the first and the other the sixth decade. Histologically the vascular tumors in both were primarily of the cavernous type. In the only other case of hemangioma of the small

bowel found in the records of the Royal Victoria Hospital there were innumerable small submucosal cavernous hemangiomas in the jejunum of a man aged 64 who died of hypertensive heart disease.

GENERAL COMMENT

Two cases of hemangioma of the jejunum complicated by intussusception are added to the meager literature on the subject. The difficulties of making a clinical diagnosis in such cases have been well demonstrated. The cases reported constitute the only instances of this combination of conditions in the records of the Royal Victoria Hospital and the Pathological Institute between the years 1915 and 1939. One other case of hemangioma of the small bowel, without intussusception, has been observed. These 3 cases comprise 1.09 per cent of all cases of benign tumor of the gastrointestinal tract from the cardia to the anus and 12.5 per cent of those of benign tumor of the small bowel.

It is not the purpose of this report to enter into a discussion as to whether cavernous hemangiomas like those occurring in my 2 cases are to be considered true tumors or simple vascular malformations. They are generally classified as neoplasms. The progressive growth and persistent recurrence which occurred in other parts of the body in the second case certainly indicate a neoplastic process. Should the reader be interested in this subject, reference may be made to the studies of Sabin [18] and of Geschickter and Keasly.[19]

SUMMARY AND CONCLUSIONS

Hemangiomas of the small bowel are rare, and complications due to intussusception are very infrequent. This complication is serious and often fatal and may be suspected whenever symptoms of intestinal obstruction and hemorrhage occur with a history or evidence of hemangiomas elsewhere in the body. Two cases of this comparatively rare condition are reported

18. Sabin, F. R.: Preliminary Note on the Differentiation of Angioblasts and the Method by Which They Produce Blood Vessels, Blood Plasma and Red Blood Cells as Seen in the Living Chick, Anat. Rec. **13**:195, 1917.

19. Geschickter, C., and Keasly, L. E.: Tumors of Blood Vessels, Am. J. Cancer **23**:568, 1935.

PRODUCTION OF EXPERIMENTAL TUMORS OF THE BRAIN WITH THE SHOPE RABBIT PAPILLOMA II

BARNES WOODHALL, M.D.
AND
ROBERT W. GRAVES, M.D.
DURHAM, N. C.

The gross characteristics of extradural and subdural growths produced by implantation of virus-induced cutaneous rabbit papilloma [1] and the reaction of the brain to such experimental tumors have been described briefly.[2] It was noted in a small series of implantations that the intracranial growths were essentially similar to those observed following implantation in other tissues of the host. The proliferating epithelium of the individual growths did not invade the adjacent nerve tissue, and the growths thus presented the picture of slowly expanding intracranial tumors. Histologic study showed that there was no glial reaction when implantation was extradural and a layer of meninges was interposed between the tumor and the brain. When, on the other hand, the tumor was implanted subdurally, thus coming into more direct contact with the parenchyma of the brain, there was always proliferation of astrocytes with formation of numerous fibers, which were attached to the tumor cells.

In the preliminary studies, difficulty was encountered in obtaining growths by implantation within the brain substance. Improvements in technic have made possible the production of such growths in a high percentage of animals. In the present work the behavior of papilloma transplanted into the brain tissue has been studied. Further observations of extradural and subdural implants have been made in a larger series of animals. The results of these experiments and those of a study of the general reaction of the host to slowly expanding intracranial tumors are described here.

From the Department of Surgery and the Laboratory of Experimental Neurology, Duke Hospital.

This work was partly supported by a grant from the Committee on Scientific Research of the American Medical Association.

1. Shope, R. E.: Infectious Papillomatosis of Rabbits, J. Exper. Med. **58**: 607-624, 1933.

2. Woodhall, B.; Graves, R. W., and Beard, J. W.: Experimental Production of Tumors of the Brain with the Shope Rabbit Papilloma, Arch. Surg. **38**: 457 (March) 1939.

METHOD

The preparation of the virus, the production and histologic character of the cutaneous papilloma and the technic of extradural and subdural implantation have been described in detail.[2] Early attempts to implant the papilloma intracerebrally by injecting fragments through a short 18 gage needle were unsuccessful, but consistent implantation was accomplished in the following manner: Through a sagittal incision 4 mm. to the left of the midline of the skull a perforator opening was made in the desired longitudinal plane (in the majority of instances on the left side over area 17 as demarcated for the rabbit brain), large enough to accommodate a short, flanged ventricular needle. After preliminary incision of the dura the ventricular needle was passed into the brain tissue for a distance of 8 mm. from the surface of the skull. Ventricular fluid was frequently encountered; puncture deeper than the lateral ventricle resulted fatally in 1 instance from hemorrhage into the basal ganglions. Hashed papilloma tissue was readily pushed through the relatively large lumen of the ventricular needle. The needle was 2.5 mm. in diameter, and the necessary aperture in the skull was not large enough to destroy the conception of the skull as a rigid container.

Further studies were made by extradural and subdural implantation methods with a view toward securing tumors in these sites larger than those previously described. The rabbits were killed at various intervals after implantation of the tumor tissue and the cranial vessels were washed out with 0.9 per cent sodium chloride solution through the carotid arteries prior to fixation in alcohol or in formaldehyde–ammonium bromide solution. Thirty animals were used in the combined study; of these, 6 died during or shortly after the operative procedure, 5 were killed at appropriate intervals and were found to be without tumors, and 19 showed intracranial growths.

GENERAL CHARACTER OF GROWTHS RESULTING FROM INTRACEREBRAL TRANSPLANTATION

The papilloma was readily transplanted intracerebrally by the simple technic described. This procedure was carried out in 8 rabbits; in 5 of these intracerebral tumors were produced, and 3 animals died during implantation or within one week. One of the last-mentioned group died of hemorrhage as the result of faulty technic, and the other 2 showed satisfactory implantations but succumbed to dysentery. The general reactions of the hosts in which the 5 successful implantations were made may best be described by presenting in detail a typical protocol.

Rabbit 206, thirty-nine days after intracerebral implantation of the growth on the left side, exhibited definite signs of increasing intracranial pressure. Both forelegs were weak, the right more than the left. Muscle tone was increased in the right foreleg. Both pupils were small, the left being larger than the right. Both optic disks appeared constricted or of decreased diameter as compared with the normal, and the margins of both were elevated. Ventricular fluid had not been obtained at the time of implantation. When the animal was killed and the skull cut away, no tumor was apparent over the convexity of the brain, though the convolutions were flattened over the regions corresponding to areas 5 and 7. A cross section of the brain disclosed a subcortical tumor measuring 12.5 by 15 mm. The growth had displaced the basal ganglions to the right and had caused the development of contralateral hydrocephalus involving the ipsilateral frontal horn.

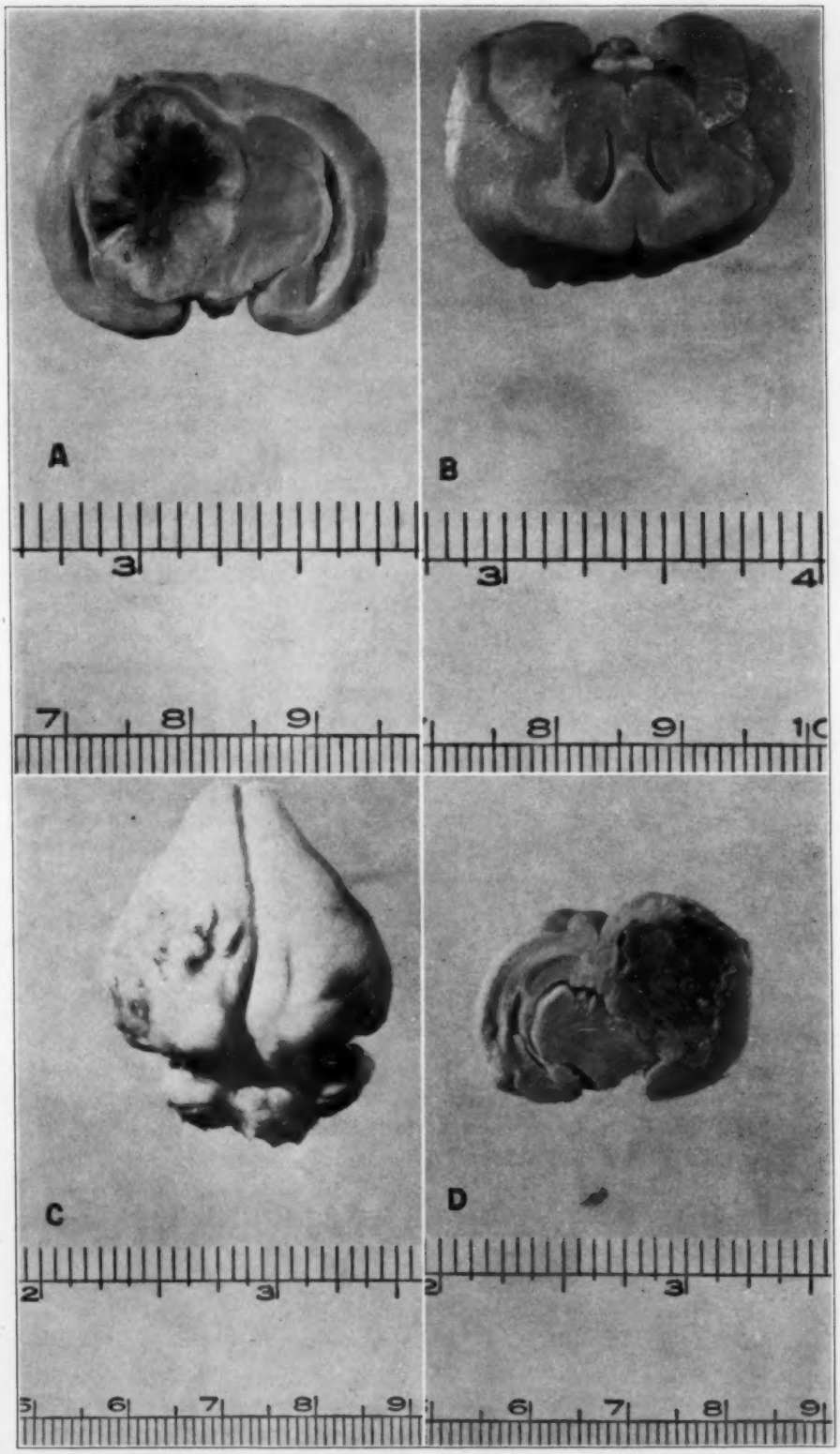

Fig. 1.—*A*, cross section of an intracerebral tumor (rabbit DR 206); × 1½. *B*, hydrocephalus resulting from a left-sided intracerebral tumor in areas 5 and 7 (rabbit DR 206); × 1½. *C*, external configuration of a hemisphere with an intracerebral tumor implanted in the left side (rabbit DR 315). The animal, not described in the text, showed paresis of the right extremities and anisocoria, the left pupil being larger than the right. The illustration is natural size. *D*, cross section of an intracerebral tumor (rabbit DR 315); natural size.

All growths, including the one just described, were situated in the left hemisphere, beneath the original bony defect, and had expanded in a concentric fashion from this median point. The tumor masses were firmly embedded in the nerve tissue and when cut across could be dislodged only by forceful manipulation. There was no gross evidence of invasion of the nerve tissue, but the growths were definitely adherent to the adjacent brain substance. In shape and general appearance the intracerebral tumors were similar to the growths described in our earlier publication.[2] They were elastic and roughly spherical, and the presenting surface of each was irregular and creamy white. On section the external layer showed as a rind of whitish succulent tissue about a dense, striated creamy or grayish black necrotic mass.

Three of the five intracerebral growths were from 11 to 15 mm. in diameter; the remaining two were 3 mm. and 5 mm., respectively. The period of maximum growth compatible with the well-being of the experimental animal appeared in this small series to be from thirty-five to fifty-two days after implantation. The 3 mm. and the 5 mm. growth were obtained, one fifteen days and the other, thirty-nine days, after; in neither instance had the animal displayed unusual neurologic manifestations. The 3 animals with large growths showed definite impairment of consciousness, progressing to deep coma in 1 instance. Two of the 3 animals showed a motor deficit with spasticity contralateral to the tumor, anisocoria with the dilated pupil on the side on which the lesion was present and a questionable abnormality of the optic disks. The third animal was not examined neurologically. All 3 showed hydrocephalus on section of the brain.

GENERAL CHARACTER OF MORE ADVANCED GROWTHS RESULTING FROM SUBDURAL IMPLANTATION

Fragments of papilloma were implanted subdurally in 10 animals in an effort to produce large intracranial growths to further the study of the effects of increasing intracranial pressure on brain tissue. Each implantation was successful in producing the desired growth. In 3 animals, rabbits DR 409, DR 320 and DR 114, killed, respectively, fifteen, twenty-one and forty-two days after implantation, small, entirely subdural growths were found; they were similar to those previously described, measuring in each instance 4 by 4 mm. The growths were fixed in appropriate solutions for histologic study.

In the remaining 7 animals the tumors were of two distinct types. Two animals showed large subdural tumors with an extension into the cerebral tissue that represented in each case a true intracerebral growth. In 5 animals the subdural-intracerebral growth was associated with an extradural tumor, the connection between the two being marked by a

thin strand of tumor cells extending through the original dural incision. In 3 of the 5 there was also an extracranial extension of the extradural growth through the tiny perforator opening in the skull. The adjacent bone was thickened and vascular. The effects of the subdural-intracerebral tumors may be described to advantage by presenting the protocol of a typical experiment.

Rabbit 168 was killed forty days after subdural implantation of tumor on the left side. At this time the animal was found lying on its right side. On examination there was no localized paresis or change in muscle tone, but the animal did not make use of its right extremities as fully as of its left. No definite change could be made out in either fundus. The left pupil was larger than the right.

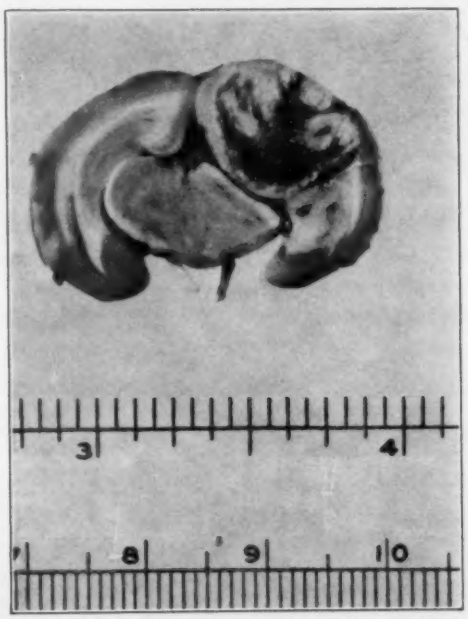

Fig. 2.—Cross section of subdural-intracerebral tumor (rabbit DR 168); × 1½.

There was a coarse, irregular nystagmus affecting the left eye, with the quick component toward the assumed center of fixation. When the scalp was reflected an extracranial tumor 3 by 3 mm. was noted protruding through the perforator opening. When the skull was removed, the intracranial tumor was apparent superficially as an oval mass 6 by 8 mm. lying in the left temporo-occipital region and extending caudally beyond the occipital pole for a distance of 3 mm. On cross section the subdural growth was found to extend as a large intracerebral growth 11.5 by 9.5 mm. which depressed the basal ganglions and expanded subcortically from area 17 into area 18. Both frontal horns of the ventricular system were dilated (fig. 2).

The remaining 5 animals had extradural-subdural growths, two of which are described in the following protocols.

Rabbit DR 122 was killed fifty-five days after subdural implantation of tumor on the right side. While being handled the animal had a generalized convulsion which seemingly involved the extremities of the left side more than those of the right. The hyperactive clonic movements persisted for twenty or more seconds, and the reaction was repeated on any passive movement of the extremities during a short period of observation. There was no anisocoria. A more detailed neurologic study was not done. When the scalp was reflected, a flat extracranial tumor 3 mm. in diameter was protruding through the perforator opening. On removal of the skull plate an extradural tumor was noted, measuring 9 by 8 mm. and projecting 3 mm. above the surrounding cortex. It was rostral to area 17 and

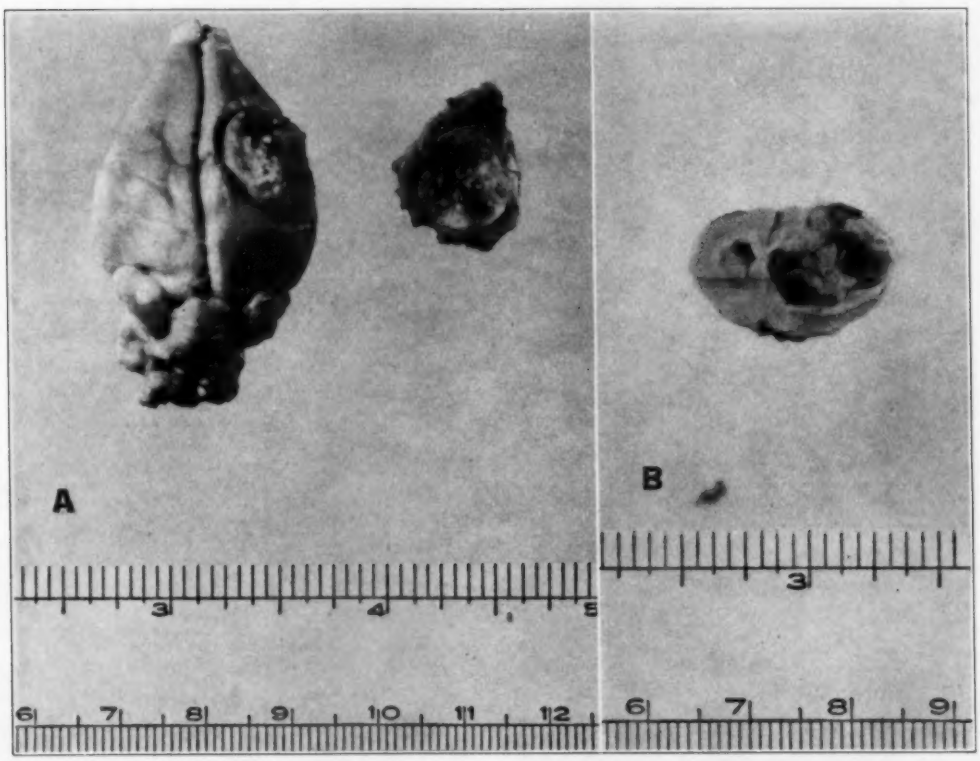

Fig. 3.—*A*, external configuration of a hemisphere with an extradural-subdural tumor in situ (rabbit DR 122); natural size. *B*, cross section of a rostrally placed extradural-subdural tumor (rabbit DR 122) with associated contralateral hydrocephalus of the frontal horn; natural size.

was the most anteriorly placed tumor of the series. Two thirds of the tumor mass was found on section to be situated extradurally and the remainder subdurally. The entire mass was 10 by 11 mm. in cross section. Marked hydrocephalus had developed in the contralateral ventricle and in the ipsilateral posterior horn (FIG. 3).

Rabbit DR 201 was found lying in its cage in a position of opisthotonos eighty-six days after a midline cerebellar implantation of tumor. Its head was held in constant retraction, and all four extremities were in extensor spasm, with a constant fine tremor of the forelegs. The animal rapidly resumed this position

on passive movement by the observer. There was no anisocoria. Both disks appeared normal. There was a persistent horizontal nystagmus with the quick component to the left in each eye, that is, forward in the right eye and backward in the left. When the scalp was reflected, a large extracranial tumor presented, measuring 14 by 11 by 8.5 mm. When the bone case was removed an extradural tumor was seen, measuring 16 by 16 mm. When the extradural tumor was lifted from its bed a subdural extension was noted, measuring 10 by 7 by 6 mm., making the entire tumor 13.5 mm. in depth. This huge tumor compressed both occipital poles, particularly the left, and formed a deep indentation in the anterior third of the cerebellar vermis. The left half of the pons was markedly compressed, and the defect on the right side was perhaps one third as deep. The

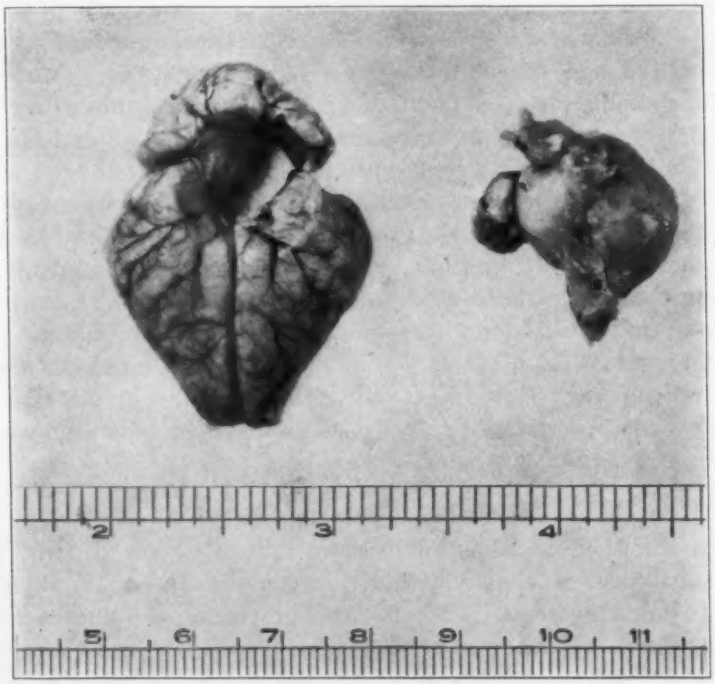

Fig. 4.—Displacement of the occipital poles and the anterior third of the vermis by an extradural-subdural tumor (rabbit DR 201); natural size.

floor of the third ventricle could be seen bulging through the base of the brain. Coronal hemisection of the hemisphere disclosed the most extensive hydrocephalus observed in this series of intracranial growths (fig. 4).

Five of the 10 animals with advanced subdural growths ranging in diameter from 9 to 14 mm. exhibited clinical evidence of increasing intracranial pressure, and in 3 animals neurologic changes were demonstrated. Such changes included contralateral motor paresis and spasticity, anisocoria, questionable changes in the optic disks and nystagmus. As has been noted in the protocols, 1 animal showed a convulsive state, and a second exhibited the picture of persistent opisthotonos. Hydro-

cephalus was noted on gross examination of all 5 specimens. With this type of implantation the maximum period of growth compatible with the life of the experimental animal was somewhat longer than with the intracerebral type, ranging from forty to eighty-six days.

FURTHER STUDIES OF INTRACRANIAL GROWTHS PRODUCED BY EXTRADURAL IMPLANTATION

Fragments of papilloma were implanted extradurally in 9 additional animals. In the earlier study of tumors produced in this manner, two such implantations had resulted in small extradural growths after twenty-one and forty-two days, respectively. In the present series of animals, 5 showed no evidence of an extradural growth fifty-six to one hundred and thirty-three days after implantation. Two of the remaining animals had small extradural tumors, 3 by 4 mm., after forty-four and one hundred and nineteen days, respectively, and the third showed a larger tumor, 8 by 9 mm., fifty-four days after implantation. The fourth animal was found moribund in its cage fifty-two days after implantation. No neurologic examination could be made. An extradural tumor 15 by 12 by 7 mm. was found over area 17, greatly compressing the cortex, shifting the basal ganglions far to the opposite side and producing contralateral hydrocephalus. It is probable that the failure to secure successful implantation in the majority of animals and the comparatively slow rate of growth of the implants in the remainder (with a single exception) were due to the relative avascularity of the site of implantation.

SUMMARY AND CONCLUSION

The cutaneous papilloma induced in rabbits by the virus of infectious papillomatosis was transplanted intracerebrally in 5 of 8 animals. Massive tumors were produced in a large proportion of fourteen successful extradural and subdural implantations in 22 individual experiments.

Implants within the brain tissue exhibited a high rate of growth and expanded rapidly, in contrast to the more slowly growing extracerebral masses. The contrast was especially marked in the extradural implants, which increased in size exceedingly slowly and in many cases failed entirely to develop. These differences in rate of growth among implants in the three sites may possibly be attributed to the relative vascularity of the respective sites.

The clinical manifestations of increased intracranial pressure, the suggestive changes in the optic disk, the localized neurologic deficit, the extensive alteration in the form of the adjacent nerve tissue and the presence of hydrocephalus are findings in this particular experimental animal which are indisputably similar to those seen in human beings suffering from intracranial neoplasm.

SEVENTIETH REPORT OF PROGRESS IN ORTHOPEDIC SURGERY

JOHN G. KUHNS, M.D.

SUMNER M. ROBERTS, M.D.

ROBERT J. JOPLIN, M.D.

WILLIAM A. ELLISTON, F.R.C.S.

AND

GEORGE BAILEY, M.D.

BOSTON

JOSEPH A. FREIBERG, M.D.

CINCINNATI

JOSEPH E. MILGRAM, M.D.

NEW YORK

AND

FREDERICK E. ILFELD, M.D.

LOS ANGELES

CONGENITAL DEFORMITIES

Early Diagnosis of Congenital Dislocation of the Hip.—Fairbank [1] states that a normal anatomic result can follow congenital dislocation of the hip only when diagnosis is made early, i. e., within twelve months. During this period, simple reduction of the dislocated hip will usually result in cure. When displacement of the femoral head is not great the following points on roentgen examination suggest congenital dislocation: shelving of the upper portion of the acetabulum, decrease in size of the center of ossification and displacement of the femur upward and outward.

Arthrography in Congenital Dislocation of the Hip.—Severin,[2] at the Orthopedic Clinic in Stockholm, Sweden, has been able to outline the hip joint in roentgenograms by means of a solution of perabrodil (skiodan; sodium monoiodomethane sulfonate). The material is injected into the hip joint with a modified lumbar puncture needle. From a study of the normal hip in 60 children from 1 to 13 years of age the author has

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This report is compiled from a review of 151 papers selected from 223 titles concerning orthopedic surgery which appeared in the medical literature approximately between March 1, 1937 and July 1, 1939.

1. Fairbank, H. A. T.: Brit. M. J. **1**:607, 1939.

2. Severin, E.: J. Bone & Joint Surg. **21**:304, 1939.

observed that the acetabular lip lies 1 to 2 mm. above the horizontal line through the Y-shaped cartilage; that the cartilaginous portion of the acetabulum should cover at least half the femoral head; that there should be only a small amount of contrast medium at the bottom of the acetabulum, and that the femoral head should be spherical. In hips which are subluxated a varying displacement of the head upward and laterally is observed, resulting in accumulation of a large amount of the contrast material in the bottom of the acetabulum. The acetabular lip is pushed upward, and the cartilaginous portion of the acetabulum covers less than half the femoral head. When complete dislocation of the femoral head has occurred, the acetabular lip is in normal position again. No irritation from injection of the material has been observed. Roentgenograms are taken immediately after the injection.

Skeletal Traction as a Preliminary Procedure for Congenital Dislocation of the Hip.—Crego [3] cites the following advantages for traction in treatment of dislocation of the hip: It avoids sectioning or removal of resistant soft parts; it avoids the use of the hip skid as well as the use of the considerable force which is required to lever the femoral head into place after the reduction can be effected; it avoids damage to the head, which frequently accompanies forcible closed manipulation, and it prevents the continuous intra-articular pressure which follows such reduction. The author describes a traction box. Stainless steel wires 0.08 inch (2 mm.) in diameter were substituted for the usual Kirschner wire of the diameter of 0.0625 inch (1.5 mm.). These wires are threaded on each end so that tension can be obtained by tightening ordinary bicycle spoke nipples on the ends of the wires against the bows. An ordinary trocar with a bore just large enough to admit the wire completes the necessary equipment. The technic consists of inserting the trocar directly through the soft part to the shaft of the femur, ½ to ¾ inch (1.3 to 1.9 cm.) proximal to the level of the adductor tubercle. The center of the shaft is located at this level, and the trocar is inserted through the bone and then through the soft parts on the other side. The wire follows, and the bow is attached. All this is done with sterile precautions. The patient is then put to bed on a Bradford frame, and traction is applied to the bow, the foot of the bed being elevated in order that the body weight may be used as countertraction. For children under 4 years of age the initial weight used is about 10 pounds (4.5 Kg.). When roentgen examination shows the femoral head to be well down opposite the lower half of the acetabulum, the amount of traction is reduced so that there will be just enough pull to prevent upward displacement of the head, and this adjusted traction is maintained for ten days to two weeks longer. In several patients over 5

3. Crego, C. H., Jr.: J. Bone & Joint Surg. **21**:353, 1939.

years of age it was necessary to tenotomize the flexor and adductor tendons of the hip and to use 20 pounds (9 Kg.) of traction for as long as a month before the head had completely descended. If the acetabulum is too shallow or its roof too nearly vertical to permit permanent reduction or if closed reduction cannot be effected without an anesthetic, open operation is indicated. The author used skeletal traction as a preliminary procedure to either open or closed reduction in the cases of 27 children under the age of 7 years with posterior dislocation of the hip. In 11 cases the deformity was bilateral, making a total of 38 hips treated. Twenty-nine of these hips were reduced spontaneously without anesthesia. Nine were reduced by open reduction. The author elimimated 5 cases in which the patients were still in plaster at the time of writing and 5 in which there was femoral torsion, an inadequate acetabulum, or both, but of the remaining 28 the results were entirely satisfactory anatomically in 25.

Fracture Healing in Osteopsathyrosis Idiopathica.—Sonnenschein [4] reports an operation on each of 2 patients with severe osteopsathyrosis. The first was step approximation of the ends of a pseudarthrosis. Union was solid in ten months. In the second case there was marked anterior bowing of the tibia. A wedge resection was performed. Union was solid in four months. Sonnenschein observed that periosteal callus formed normally, although endosteal callus formation was delayed. He feels that one need not refuse osteotomy or surgical correction of pseudarthrosis in these patients.

NUTRITIONAL DISTURBANCES OF BONE

Citrates in Treatment of Infantile Rickets.—Shohl and Butler [5] report 2 cases of infantile rickets in which healing was induced by mixtures of citric acid and sodium citrate. They believe that this new form of therapy is a valuable adjunct to the accepted measures of treatment, especially in case of resistance to vitamin D therapy. They suggest that the new therapy may be applicable to other types of disorders of calcium and phosphorus metabolism.

DEVELOPMENTAL DISEASES

Endocrine Implication of Juvenile Chondroepiphysitis.—A group of 259 patients 8 to 15 years of age with endocrine pathologic conditions were examined. Ninety-one, or 35.2 per cent, displayed evidence of single or multiple chondroepiphysitis (Köhler's disease, Legg's disease, Osgood-Schlatter's disease, Freiberg's disease). Eighty-five per cent of the 91 showed clinical or laboratory evidence of primary or secondary

4. Sonnenschein, A.: Zentralbl. f. Chir. **65**:1970, 1938.
5. Shohl, A. T., and Butler, A. M.: New England J. Med. **220**:515, 1939.

hypothyroidism. A control group of 99 patients without endocrine disease in the same age range included only 7 in whom there were chondroepiphysial changes. The authors [6] concluded that chondroepiphysitis is of endocrine origin, specifically due to primary or secondary hypothyroidism, usually asymptomatic, and that chondroepiphysitis is a pathognomonic sign of hypothyroidism.

[Ed. Note: Chondroepiphysitis is in many cases associated with a physiologic disturbance in the complex endocrine system. Sufficient evidence has not been presented however, to show hypothyroidism alone to be the cause.]

TUBERCULOSIS

Paravertebral Aspiration of Tuberculous Abscess of Psoas Muscle.—Warring and Kent [7] advocate paravertebral aspiration of tuberculous abscess of the psoas muscle through the lumbar muscles. They use a 5½ inch (13.9 cm.), 15 gage needle for aspiration, local anesthesia having been induced along the path of the needle. The needle is inserted 5 cm. lateralward from the line of the vertebral spinous processes on the side of the abscess and at the level of the space between the third and the fourth or between the fourth and the fifth vertebral spinous process. The needle is "directed slowly inward, parallel to the cross section of the body and slightly lateralward." Five aspirations were performed in 2 cases. This method may be used before the abscess penetrates below Poupart's ligament. The dangers of injury to contiguous structures are mentioned.

Pulmonary Tuberculosis with Tuberculosis of Bones and Joints.—Frank [8] studied the incidence of pulmonary disease in a group of 1,003 cases of tuberculosis of bones and joints. He found that in patients up to the age of 6 years there was often an association of these lesions. Similarly, in the aged an osseous lesion was frequently associated with an active tuberculous lesion. In the aged it was likely to be cavernous advancing tuberculosis. However, between the ages of 10 and 30 the incidence of associated active pulmonary disease was rare. Only 2.4 per cent of all patients showed a progressive exudative pulmonary tuberculosis together with an osseous lesion. All other pulmonary lesions were benign. The author strongly advises operative treatment of osseous foci despite the presence of corresponding lesions in the lungs. He states the belief that removal of one tuberculous focus favorably influences the entire body.

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6. Schaefer, R. L.; Strickroot, F. L., and Purcell, F. H.: Endocrine Implication of Juvenile Chondroepiphysitis, J. A. M. A. **112**:1917 (May 13) 1939.

7. Warring, F. C., and Kent, E. M.: Am. Rev. Tuberc. **39**:338, 1938.

8. Frank, H.: Beitr. z. klin. Chir. **168**:337, 1938.

OSTEOMYELITIS

Coccidioidal Osteomyelitis.—McMaster and Gilfillan [9] report 24 cases of proved coccidioidal granuloma of bone. Thirteen of the 24 patients died of pulmonary involvement. Two patients with pulmonary involvement survived. Four patients showed primary localization of the process in the synovia; in the others the condition was initially osseous. Multiple osseous lesions were more common than single ones. The importance of general as well as of local treatment is emphasized. In cases of acute involvement, with widespread lesions, conservative treatment by means of immobilization is advised. In cases of chronic involvement, surgical intervention, including incision and drainage, ankylosis of joints and even amputation, has been employed. No medication has been found to be specific.

CHRONIC ARTHRITIS

Intermittent Hydrarthrosis.—Berger [10] reviewed the incidence and suspected etiology of intermittent hydrarthrosis and came to the conclusion that the condition is not a disease but an articular manifestation of a variety of general and local conditions. He reports a case in which the symptoms proved to be due to allergy. Elimination of the offending allergens from the diet caused disappearance not only of the concomitant allergic manifestations but of the hydrarthrosis.

BACK

Pain Low in the Back and Spina Bifida Occulta.—Dittrich [11] made a study of 7 cases of pain low in the back. Four of the patients were males, and 3 were females. There was radiation of the pains, associated with congenital defects of the sacrum identified as spina bifida occulta. These defects consisted of oval to round defects in the sacral laminas, varying in diameter from several millimeters to centimeters and extending through the entire thickness of the lamina. These anomalies were accompanied by masses of fat and fibrous tissue in close contact with the nerve roots and so arranged that mechanical irritation of the nerves was produced. There were muscular tenderness, muscle spasm, limitation of motion in the back, disturbance of the deep reflexes, fatigue on exertion and more or less constant pain. Six of the 7 patients were relieved by laminectomy of the upper three sacral segments and removal of the fibroadipose tissue within the canal. In the seventh case the conditions found at operation were atypical and apparently beyond repair.

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9. McMaster, P. E., and Gilfillan, C.: Coccidioidal Osteomyelitis, J. A. M. A. **112**:1233 (April 1) 1939.

10. Berger, H.: Intermittent Hydrarthrosis with Allergic Basis, J. A. M. A. **112**:2402 (June 10) 1939.

11. Dittrich, R. J.: Am. J. Surg. **43**:739, 1939.

[ED. NOTE: When spina bifida is present one frequently finds alterations in the size and position of the spinal articular facets which can, through instability and later irritation, lead to pain in the lower part of the back.]

NEOPLASMS

Synovial Sarcomas in Bursae and Tendon Sheaths.—Berger [12] presents a comprehensive view of the subject of synovial sarcomas and publishes 4 case histories (with detailed microscopic observations) of synovial sarcoma originating in serous bursae and tendon sheaths. The lining tissue of the serous bursae and tendon sheaths is homologous with articular synovial membrane and consists of dense connective tissue through which are scattered polymorphous cells. It is composed of an outer vascular layer and an inner superficial layer containing dendritic cells. Three of the author's patients had synoviomas originating from serous bursae, two in the thigh and one in the axilla; the fourth had a tumor originating from the extensor tendon sheaths on the back of the wrist. Histologically these neoplasms are of a single tissue origin (mesenchymal) but present various morphologic modifications. The tissue consists of dense cellular masses giving rise to pseudoglandular, simple or ramifying cavities. The masses of cells are formed by branching, curved, sometimes polyhedral cells with a syncytial aspect. The histologic structure of the tumors in these 4 cases favors the conception that synovial tissue is a tissue *sui generis,* being in a broad sense part of the reticulohistiocytic system but unique in its pronounced endothelial potentiality. Synovial sarcomas are highly malignant tumors, although at first they seem to grow slowly. Synovial sarcomas of serous bursae apparently run a more rapid course than do those of articulations, and recurrences develop in almost all cases in which operation is performed. Death is generally due to pulmonary, exceptionally to cerebral, metastases. Cure may be obtained only by early amputation.

Hemangioma of Joints.—Bennett and Cobey [13] report 5 cases of hemangioma of the knee joint and give an account of 24 authentic cases previously reported in the literature. The cardinal points in the diagnosis of hemangioma are (1) intermittent pain and swelling present since early life, with or without a history of trauma; (2) no pain on motion; (3) slight limitation of motion; (4) presence of another hemangioma anywhere on the body (5) reduction in the swelling on elevation of the extremity; (6) negative results from laboratory and roentgen examinations, and (7) aspiration of blood from the joint. The treatment advised is excision for small pedunculated tumors and rest together with radium or roentgen therapy for nonpedunculated

12. Berger, L.: Am. J. Cancer **34**:501, 1938.

13. Bennett, G. E., and Cobey, M. C.: Hemangioma of Joints: Report of Five Cases, Arch. Surg. **38**:487 (March) 1939.

tumors. In 1 case an attempt at excision was followed by hemorrhage and infection, and eventually amputation was necessary. In another case complete excision was possible. Radium or roentgen therapy administered after biopsy produced practically complete recovery in 3 cases. In 4 cases the diagnosis was proved by biopsy. In the fifth case the behavior of the process made the diagnosis probable.

MISCELLANEOUS

Amputation Neuroma of Digital (Finger) Nerve.—Josefsson [14] reports 3 cases of neuroma of digital (finger) nerves causing severe pain which was incorrectly diagnosed as osteitis. Neuroma often occurs when digital nerves are cut. It is difficult to isolate the small digital nerve at operation. The best treatment is dissection of the neuroma and removal of at least 3 cm. of the nerve with the thermocautery.

Roentgen Treatment of Gas Gangrene.—Kelly and Dowell [15] report 8 cases of gas gangrene treated by roentgen therapy, with recovery in 6. Two patients with involvement of the trunk died. Through questionnaires to roentgenologists the authors were able to collect 132 cases of gas gangrene treated by roentgen therapy. Of 105 patients with gas gangrene of the extremity, 6 died. Of 18 with involvement of the trunk, 4 died. Of 9 with diabetic and arteriosclerotic gangrene, 5 died. The authors feel that roentgen therapy lowers mortality and lessens the necessity of amputation. The earlier treatment is begun, the more easily the infection is controlled. They advise administration of 100 r per port daily for three to five days.

Dupuytren's Contracture.—Smith and Master [16] undertook a study to determine whether any relation exists between trauma and Dupuytren's contracture. For subjects they chose upholsterers, who continuously use the palm. Five hundred and thirty-six men who had worked at the trade for two years or more were studied. Six cases (1 per cent) of Dupuytren's contracture were observed. In these cases the disease occurred after twenty or more years in the occupation. It was bilateral in all but 1 case. No evidence of any hereditary influence was found. This incidence is no higher than that found in other studies. The writers do not regard Dupuytren's contracture as an occupational disease.

FRACTURES AND DISLOCATIONS

Traction-Abduction for Fractures of the Arm.—Heyl [17] evaluates the results of the traction-abduction treatment for fractures of the arm.

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14. Josefsson, H.: Acta med. Scandinav. **81**:860, 1939.

15. Kelly, J. F., and Dowell, D. A.: Arch. Phys. Therapy **20**:88, 1939.

16. Smith, K. D., and Master, W. E.: J. Indust. Hyg. & Toxicol. **21**:97, 1939.

17. Heyl, J. H.: Fractures of Upper Extremity and Shaft of Humerus, Arch. Surg. **38**:295 (Feb.) 1939.

There were 106 fractures of the upper extremity and shaft of the humerus, 17 fractures of the greater tuberosity, 46 fractures of the surgical neck and 3 fractures of the shaft. These fractures were treated at the Beekman Street Hospital, New York, from 1929 to 1934, by the various members of the staff. This method was used for fractures of the upper extremity of the humerus. It required long periods of hospitalization, and a review of the end results showed no advantage or need (with exceptions) of the use of this method for these fractures.

[ED. NOTE: This method has its use in individual cases but should not be applied to all the fractures of the humerus under discussion. Whether this method is still used for these fractures is not stated.]

Operative Treatment of Dislocation of the Head of the Radius.—Aside from the common so-called luxation of the radial head (which the French aptly call *pronation douloureuse*), isolated dislocation of the radial head is a comparatively rare lesion: It usually occurs in childhood. In adults it is often associated with fracture of the shaft of the ulna. Frequently the deep branch of the radial nerve is injured in the supinator canal. The dislocation is usually volar. While closed reduction may be attempted, the author's [18] experience is that accurate reduction can be obtained only by open operation. The fibrous ring from which the head has slipped must be incised and the head replaced, after which suture is performed. When the head is reduced it stays well in position. The 3 cases reported emphasize the foregoing points. In a case in which operation was performed one and one-half years after dislocation, resection of the scarred ring and ligaments was necessary before reduction was obtainable. Extension of the elbow lacked 45 degrees at the termination of treatment in this case. Early recognition and operation are stressed.

Nonunion of Carpal Navicular Bone.—MacCallow [19] states the opinion that nonunion of the carpal navicular bone is the result of defective treatment, frequently of failure to recognize the presence of a fracture early. All injuries to the wrist with tenderness over the navicular bone should be treated by splinting, and roentgenograms should be taken in two weeks. Although a fracture may not be evident immediately after injury, it will be shown after two weeks. The splint, with the hand in dorsiflexion and radial deviation, should be worn for eight to twenty weeks; during this period vigorous use should be encouraged. When nonunion is found, splinting for six months may be tried, but this method is uncertain. The author has found that removal of the dead bone does not lessen disability. He advises cross drilling of the fragments and splinting for twelve weeks. In 13 patients with nonunion so treated, union has occurred.

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18. Lotsch, F.: Zentralbl. f. Chir. **37**:2038, 1939.
19. MacCallow, F. H.: M. J. Australia **1**:391, 1939.

Treatment of Fractures of the Neck of the Femur.—At the fourth Congress of the International Society of Orthopaedic Surgery and Traumatology there was a symposium [20] on fractures of the neck of the femur. Dr. Lothar Kreuz, of Berlin, Germany, stated that extra-articular nailing of true cervical fractures gives the best chance of avoiding hindrance to healing. It is the quickest, safest and most successful method for patients between the ages of 70 and 80. For adults up to 60 conservative treatment gives about the same end results. For children conservative treatment alone is indicated. Dr. Sven Johansson, of Sweden, described his method of guiding a Smith-Petersen nail into the head of the femur after accurate reduction. This method he uses also for young patients. He states that satisfactory healing occurs in 90 per cent of the patients who survive. Dr. Adam Cruca, of Poland, stressed the necessity of revascularization of the femoral head for healing of the fracture. He stated the belief that this is best aided by correct reduction and fixation with a nail. He reported 93.4 per cent of favorable late results by his technic of subcutaneous nailing. According to Dr. Louis Tavernier, of Lyons, France, fractures are a mechanical and not a biologic problem. Correct reduction with extra-articular osteosynthesis gives good results in about 80 to 85 per cent of cases. Ten to 20 per cent of the patients later have chronic arthritis. For late pseudarthroses the author advises a transtrochanteric osteotomy. Drs. José Valls and Enrique Logomarsino, of Buenos Aires, Argentina, distinguished between the treatment of recent fractures and that of old fractures. Extra-articular osteosynthesis is the best method for recent intracapsular fractures. They reported 82 per cent of good results, with a 4 per cent mortality. For old fractures of which a satisfactory reduction can be obtained, they recommend osteosynthesis. When good reduction cannot be secured, intertrochanteric osteotomy has given the best results.

Overgrowth of Femoral Shaft Following Fractures in Childhood.—An "end result study" of 59 fractures of the femoral shaft in children under 16 years of age was made by Aitken and his associates.[21] A film 4 feet (121 cm.) long with a special cassette was used, with the child standing erect and the tube placed at a distance of 7 feet (213 cm.) in order to obtain accurate measurements. The patients were divided into two groups, one composed of children 13 years of age or over and the other of children 12 years of age or under. There were 6 patients in the first group. The time since fracture averaged five years. In all these cases the fragments were either anatomically reduced or laterally displaced without shortening. In 5 there was an average shortening of 1 cm., despite the fact that in none of these was there shortening on

20. Intracapsular Fractures of the Femoral Neck, Compte rendu du Congrès International de Chirurgie Orthopédique, Berlin, 1939.

21. Aitken, A. P.; Blackett, C. W., and Cincotti, J. J.: J. Bone & Joint Surg. **22**:334, 1939.

discharge. In the second group there were 44 children. In 7 of these the fragments were anatomically reduced. In 1 there was no difference in the length of the femur at the time of writing. In the remaining 6, the fractured femur was longer. The overgrowth averages 1.1 cm. Three patients were discharged with lateral displacement without shortening. These now show an increase in the length of the fractured femur averaging 0.6 cm. Twenty-nine patients were discharged from the hospital with complete displacement and overriding of the fragments. In 15 of these the femur on the fractured side is now longer than on the sound side. Nine of these were discharged with an average shortening of the femur of 1.2 cm., and the femur is now 0.4 cm. longer than on the sound side. The remaining 6 patients were discharged with an average shortening of 0.6 cm. There were 14 patients who still showed some shortening. Eleven of these were discharged, with an average shortening of 1.3 cm. In each of these the fractured femur is still 0.5 cm. short. This shows an average overgrowth from the position on discharge of 0.8 cm. In the entire series 29 patients discharged from the hospital with over-riding of the fragments, there was an average overgrowth of 1.1 cm. By way of summary, fractures of the femoral shaft in children between the ages of 13 and 16 years are apt to show eventual shortening, whereas fractures of the femoral shaft in children under 13 years of age in a great majority of instances show overgrowth of the femoral shaft.

Insufficiency Fractures of Femur and Tibia.—Hansson [22] reports 3 cases of callus formation along the longe bones subsequent to slight trauma, with no fracture line visible. In each case there was local pain, worse on use of the limb. The author states the opinion that these fractures were due to overexertion to static overload. A similar picture is seen in cases of dietary deficiency. Such callus formation is sometimes mistaken for tumor formation.

Posterior Dislocation of Lower Femoral Epiphysis.—Burman and Langsam [23] describe a rare injury, posterior dislocation of the lower femoral epiphysis, occurring during a breech delivery. The dislocation is associated with femoral subperiosteal hemorrhage which may show advanced ossification under the lifted periosteum in eight to eighteen days on the roentgenograms. In the writer's case two attempts at manipulation to replace the epiphysis were unsuccessful. The epiphysis was displaced posteriorly, laterally and proximally. At open operation the epiphysis was replaced. After this, manipulation was again resorted to, in order to correct a slight displacement. Roentgen examination approximately two months after birth revealed remodeling of the shaft

22. Hansson, C. J.: Acta radiol. **19**:554, 1938.

23. Burman, M. S., and Langsam, M. J.: Posterior Dislocation of Lower Femoral Epiphysis in Breech Delivery, Arch. Surg. **38**:250 (Feb.) 1939.

and central placement of the lower femoral epiphysis. Roentgenograms taken approximately nine months after birth revealed the epiphysis to be slightly tilted, the epiphysial line somewhat irregular and the shaft narrowed but assuming an almost normal contour. The child was followed to the age of 14 months. The child walked well. There were a lack of 5 degrees of extension and a shortening of ½ inch (1.3 cm.) in the involved extremity. Résumés of 3 previously described cases are recorded. It is the writer's opinion that manipulation or open reduction is not indicated, since nature itself remedies the defect.

Operative Treatment of Avulsion Fractures of the Eminentia Intercondyloidea.—Confronted with an avulsed eminentia intercondyloidea in the knee of a 10 year old boy, Paas [24] resorted not to extirpation of the fragment or to attempts at obtaining healing by maintenance of extension but to replacement of the fragment. He accomplished this by drilling a hole from just above the tibial tubercle to the bed of the avulsed fragment. He then transfixed the fragment with a heavy silk suture and passed both ends of the suture down through the canal, securing them externally in the substance of the patellar tendon. This held the fragment in accurate contact with its bed. Roentgenograms taken one and one-half years later reveal excellent union. The result was a normal knee.

[ED. NOTE: The method should be noted. It seems worth copying.]

Dislocation of Lisfranc's Joint.—Jazikoff [25] reports 3 cases of dislocation at the tarsal-metatarsal joint and states that only 180 cases have been published in the literature. This is a rare traumatic lesion, caused by direct and great violence and often accompanied by fractures of the metatarsal and tarsal bones and by rupture of vessels and ligaments. Treatment consists in attempts at closed reduction as soon as possible. Some authors report that reduction is very easy, but Jazikoff agrees with those who find that in many cases reduction is incomplete owing to obstruction by fragments of bone and torn ligaments. Of 32 cases described in the Russian literature, satisfactory reduction was obtained in only 11. There is a strong tendency to redislocation after reduction. Open operation is indicated only when the first metatarsal bone is dislocated, in order to free the interposed anterior tibial tendon. The prognosis should be guarded, but with good reduction and no associated fractures the results are good.

Fractures and Fracture-Dislocation of the Astragalus.—Miller and Baker [26] discuss fractures and fracture-dislocations of the astragalus, presenting facts regarding anatomy, function, types of fracture and their treatment. A brief review of the literature is included. For fractures

24. Paas, H. R.: Arch. f. orthop. u. Unfall-Chir. **39**:51, 1938.
25. Jazikoff, D.: Rev. d'orthop. **26**:126, 1939.
26. Miller, O. L., and Baker, L. D.: South. M. J. **32**:125, 1939.

of the neck and body with displacement the need for recognition and accurate replacement is stressed. For fractures with displacement of the fragments early open reduction is usually necessary to assure accurate reposition and to avoid aseptic necrosis. Incision in front of and behind the ankle may be necessary for accurate reposition of the fragments. In cases of damage to the cartilage of the subastragaloid joint and subsequent pain in the joint, triple arthrodesis is advised. At times panastragaloid fusion is necessary. Astragalectomy in adults as a means of improving the impaired blood supply in astragalar fractures is condemned. A tabulation of the type of fracture and of the end results in 30 cases of fracture of the astragalus is given.

Fractures and Pregnancy.—Lampert [27] adds 4 cases to the rather small number appearing in the literature. In 3 the fractures were pelvic. In these, as in the reported cases, union was prolonged past the usual dates. In 1 of his cases a large exostosis existed on the pubis, the consequence of a fracture sustained four months before the patient became pregnant. During the succeeding pregnancy the exostosis was spontaneously absorbed, and a normal delivery ensued. The author agrees with the opinions expressed in the literature that bony union in maternal fractures is delayed during the first and middle thirds of gestation. During the last three months rapid bone formation occurs.

ORTHOPEDIC OPERATIONS

Tendon Transplantation in the Upper Extremity. — Steindler [28] emphasizes the following principles for tendon transplantation: 1. Any contracture should be corrected in order that the limb may be passively brought through the range of motion without the slightest resistance. 2. The muscle selected should have a similar or related action. 3. The integrity of the muscle unit must be respected. 4. The transplanted muscle must have adequate power. 5. The tendon pull should be on a straight line. 6. The tendon should be transplanted under suitable tension. 7. The tendon should be anchored securely, preferably by periosteal or bony attachment or, if tendon to tendon attachment is carried out, by the buttonhole suture. 8. The gliding apparatus should be preserved. In discussing the application of tendon transplantation to the upper extremity, Steindler describes procedures to aid abduction of the arm, flexion of the elbow, extension of the wrist and fingers and opposition of the thumb.

End Results of Tendon Suture of Arm and Hand.—Heck [29] considers the advisability of primary and secondary suture of severed tendons. He reviews the previous statistics and emphasizes the differ-

27. Lampert, J.: Arch. f. orthop. u. Unfall-Chir. **39**:675, 1939.
28. Steindler, A.: Am. J. Surg. **44**:260, 1939.
29. Heck, F.: Arch. f. orthop. u. Unfall-Chir. **39**:21, 1939.

ence of opinion existing in well informed circles. By far the largest series of tendon sutures is that reported by Zweigbergk, of Sweden (688 tendon sutures). In 65 cases of primary suture a good result was obtained (80 per cent of the extensor tendons and 45 per cent of the flexor tendons). In 35 cases of secondary suture 25 extensor tendon sutures eventuated in 22 good and 3 bad results. The results of secondary suture of 7 flexor tendons were good in 6 instances and bad in 1. The author then presents his own series of 75 cases of injuries to the tendons of the hand observed at the Würzberg clinic. Primary suture was carried out on the extensors 31 times, on the flexors 23 times and on both 5 times. There were good results with 64.6 per cent of the extensors and with 43.4 per cent of the flexors. Secondary suture was carried out 16 times (8 extensors and 8 flexors). It was successful in 62.5 per cent of the extensors and in only 25 per cent of the flexors. In general, the author prefers primary to secondary suture, which he reserves for tendon injuries with extensive soft tissue damage.

Arthroplasty of the Hip.—Instead of covering the reshaped surfaces of a joint with a membrane to prevent ankylosis, Smith-Petersen [30] uses an inert mold made of vitalium over the head of the femur in arthroplasty of the hip. He describes his operative technic in detail, with excellent line drawings. The incision is similar to that which he describes for acetabuloplasty. Points in operative technic which deserve emphasis are: 1. The utmost respect for anatomic structures should be observed. Intrapelvic exposure of the acetabulum is preferable (occasionally reflection of the sartorius muscle from the anterior superior iliac spine is necessary). 2. Reflection of the origin of the gluteus muscles from the lateral aspect of the ileum should be done to facilitate dislocation of the hip. 3. After the anterior capsule has been excised, any overgrowth of the head of the femur should be removed before dislocation of the hip is attempted. 4. Complete removal of the anterior capsule and of the Y ligament of Bigelow is necessary to prevent excessive formation of scar tissue.

Postoperative treatment consists of suspending the extremity in a Hodgen splint with a Pearson attachment. At the end of the second week roller skating exercises are started. A roller skate is attached to the back of the ankle, and the patient takes abduction-adduction exercises over a board which can be tilted to produce more or less resistance as muscular strength increases. This is followed by exercise on a stationary bicycle and in a walker. No end results are reported since the 29 patients for whom the vitalium mold has been used have all been operated on since June 1938.

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30. Smith-Petersen, M. N.: J. Bone & Joint Surg. **21**:269, 1939.

Repair of Anterior Cruciate Ligament of Knee.—Campbell [31] gives the end results of repair of the anterior cruciate ligament of the knee joint. In 8 cases repair was done by the method of Hey-Groves, and in 14 cases the writer's technic was employed. The latter procedure was described in 1936. A strip of quadriceps tendon, capsule and patellar ligament 8 inches (20 cm.) long and ⅓ inch (0.8 cm.) wide is obtained from the anteromedial aspect of the knee. This strip is left attached to its lower end and passed through a drill hole in the inner tuberosity of the tibia. It emerges at the tibial attachment of the anterior cruciate ligament and through a second drill hole in the external femoral condyle is fixed to the fascia lata or to the periosteum of the femur. The operations were performed on patients between the ages of 18 and 25 years. There were excellent results in 13 cases; in 2 the results were poor and in 7 the patient could not be followed. The medial semilunar cartilage was removed in 18 cases; the external, in 1. The author expresses the opinion that independent rupture of the anterior cruciate ligament causes definite disability and must be repaired to secure maximum function.

Surgical Treatment of Spastic Paralysis.—This study by Heyman [32] was based on 280 operations on 176 patients. The patients selected for operation were from a group of approximately 1,500. Surgical treatment was considered merely an adjunct to a broad therapeutic regimen. The value of motor nerve branch resection of the internal popliteal, obturator and sciatic and the external popliteal and median nerves is discussed in detail. The operation is considered of great value for the lower extremity and of limited value for the upper. Tendon transplantations and arthrodesis of the wrist did not disclose any single satisfactory method of improving the spastic hand. The most satisfactory results followed arthrodesis of the wrist combined with crossed tendon transplantation to the dorsum of the wrist or the finger extensors. Transplantation of the hamstring tendons with the patella to reenforce the quadriceps was less successful than transplantation of the insertion of the patella tendon downward. Arthrodesis of the subastragalar region was successful if accompanied by proper tendon transplants.

RESEARCH

Experimental Bone Sarcoma.—Hellner [33] describes the development of bone sarcomas in the growth area of rabbits' knees after exposure to radium for one and one-half to two years (3 sarcomas in 5 animals). He does not use the radium-petrolatum plug in the medulla, as some workers have done, but uses external irradiation. In a series of 8

31. Campbell, W. C.: South. M. J. **32**:442, 1939.
32. Heyman, C. H.: Surg., Gynec. & Obst. **68**:792, 1939.
33. Hellner, H.: Beitr. z. klin. Chir. **168**:538, 1938.

animals he combined irradiation with the production of a suppurative staphylococcic arthritis. One animal of this group had a sarcoma. He states the belief that infection neither expedites nor delays the development of a bone sarcoma due to radium. The rays exert a specific sarcoma-evoking action, particularly on areas where increased new cell formation is in process.

Growth in Length of Vertebrae.—Haas [34] carried on experiments in dogs to demonstrate that growth in length in the vertebrae takes place by proliferation at the epiphysial cartilage plate. Markers were placed in the epiphyses and in the body of one vertebra, and another marker was placed in an adjacent vertebral body. Roentgenograms taken after one hundred and twelve days and compared with those taken at the beginning of the experiment revealed that markers in the same body were not any farther apart. The markers in the epiphyses had separated from each other, from those in the bodies and from that in the adjacent body. These experiments are similar to those of John Hunter, who demonstrated the same fact in the long bones. As yet this fact has not been shown to hold for growth in length in the vertebrae of man.

Peripheral Circulatory Disturbances in the Development of Osteoarthritis.—Kling [35] studied the joints and blood vessels in 13 cases of amputation for gangrene following chronic disease of the peripheral blood vessels. He found the lesions of osteoarthritis not more extensive or frequent than in a group of persons of similar age with normal peripheral circulation. Pronounced osteoarthritis was present in only 2 instances. In severe arteriosclerosis the synovial vessels were involved less than were vessels elsewhere.

Role of the Three-Flanged Nail as a Foreign Body.—Felsenreich [36] studied sections of the neck obtained at varying dates after nailing and reports the evidence obtained as pointing to the value of the method. He has studied the foreign body aspect. In a section observed nine weeks after nailing the contiguous lamellas about the nail were walled off from the nail by newly forming bone. Uniformly (even with the most satisfactory brands of stainless steel), rest forms, and rust granulomas regularly form. They are of interest but seem in no way to hinder bone formation in the fracture area. After removal of the nail they are absorbed. The canal in which the nail lay was replaced by connective tissue and eventually by bone. The three pigments observed in the rust granulomas disappeared histologically. The reaction of bone in the neck of the femur to a foreign body is somewhat different from that of bone in the long shafts.

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34. Haas, S. L.: Growth in Length of Vertebrae, Arch. Surg. **38**:245 (Feb.) 1939.

35. Kling, D. H.: Am. J. M. Sc. **197**:358, 1939.

36. Felsenreich, F.: Arch. f. klin. Chir. **194**:584, 1939.

Obituaries

HARVEY CUSHING, M.D.

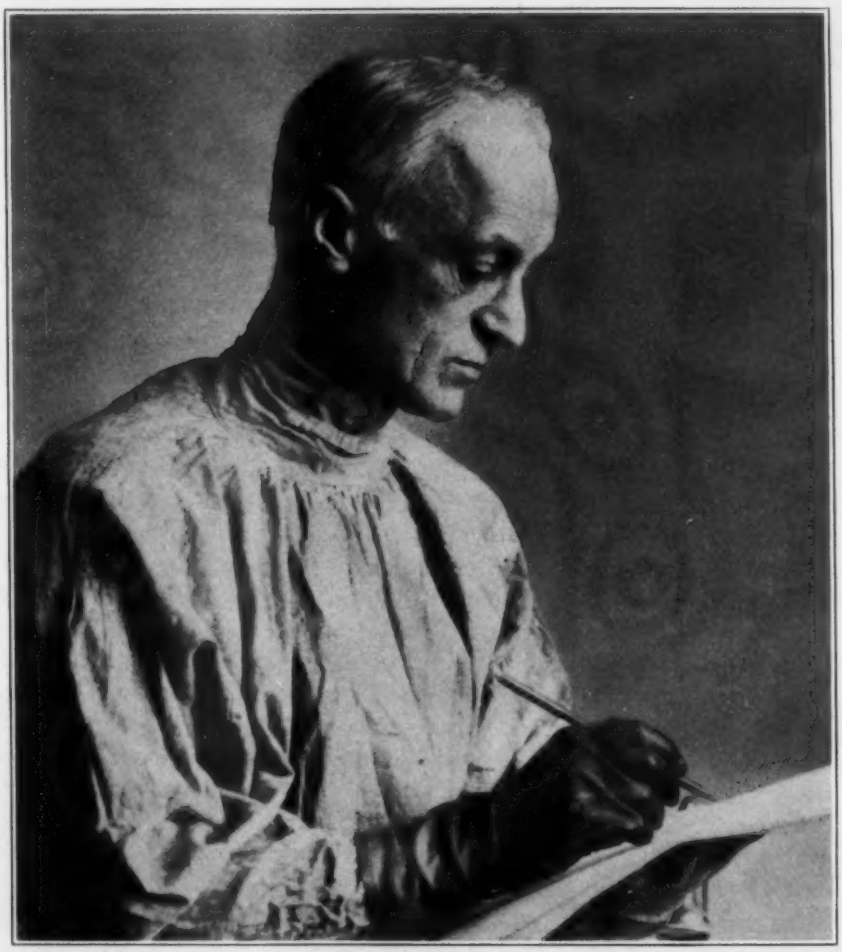
1869-1939

The bare facts of the life of Harvey Cushing may be found in many places, but it will be some time before words can be written which will convey the complete picture of this man, who was surgeon, author, artist, bibliophile, soldier and scientist.

There was a great similarity in many respects between his life and that of Sir William Osler, and there are those who believe that Cushing deliberately patterned his thoughts and mode of life after that great physician. Cushing, however, was too great an individualist to carry his idealization of a character to the point of aping him and would have denied vehemently that he had ever looked at Osler with anything but a respectful and admiring critical eye. Nevertheless, his membership in that informal group of chosen young men in Baltimore, the "latch-keyers," who had free access to Osler's home and thereby were exposed to the informal, affectionate discourses given on great men and books in medicine and to the stimulating prods delivered in an apparently casual manner had a profound effect on Cushing's character. It was through the pages of his Pulitzer prize–winning biography that a younger generation came to know Osler, and it was when Cushing was discussing "the chief" that he exhibited his greatest charm. Some day the affection, admiration and respect which he bore his older brother, Edward, will be brought to light. A few of his more intimate young associates were told of the bonds which united him to "Ned," entirely dissimilar though they were in every way. Try as hard as he might, the younger man could never exhibit the infinite patience, tolerance and camaraderie displayed by his brother. It was in his nature, but it was inhibited by a driving ambition to reach perfection.

One often wonders what the procession of thoughts was in the mind of the young doctor who had just completed his surgical residency when he asked for the privilege of devoting his future to surgery of the nervous system on the staff at Johns Hopkins Hospital. A glimpse is given in his story of "Neurological Surgeons," when he tells briefly of the hours of study and effort spent at the bedside of an unfortunate Negro who had been paralyzed by a bullet lodged within the spinal canal. It is difficult for physicians of the present generation to realize that it was necessary for him to crank the machine to generate enough current to obtain the roentgenogram by which the level of the bullet was located. This persistence and attention to detail had been manifested at

an earlier period in the meticulous records which he had kept of his patients when he was an intern at the Massachusetts General Hospital. Free hand sketches which illustrated the salient points in the findings at physical examination or at operation gave originality and character to his notes, and when, after a friendly bet with a fellow house officer as to



HARVEY CUSHING, M.D.
1869-1939

which one could administer ether without causing the patient to vomit, he kept an accurate graph of the pulse rate and respirations, it was the first such record and the forerunner of the more elaborate "anesthesia charts" used today. This desire to attain perfection in whatever he undertook was the motivating force which characterized Cushing's professional life. An operation was either good or bad. There was nothing between.

A stern and unrelenting taskmaster, he was no less demanding of his own time and physical and mental effort than of those of his associates. Those who have seen him sitting beside a patient recently operated on, aiding in the details of the nursing, have realized how concentrated was his interest in the patient's future. It was his desire to know more than the details of the patient's illness; there were the patient's personality, occupation, ancestors, domestic life, avocation and other items, which others might consider trivial, to be included in the balanced picture which made of the patient a surgical problem. To wrestle with that problem from the beginning to the end and not be merely a middleman surgeon; to "keep score" on his own efforts with self-searching honesty; to profit by the judgment which comes from recognizing and considering mistakes, was a game, which he often compared to golf. According to Cushing, every surgeon should be always striving to better his own par.

An ugly scar left by an osteoplastic craniotomy was the sign of a poorly performed operation, though the tumor had been removed and the patient had been socially and economically restored. The artistry of his operative procedures, admittedly time consuming, could never be understood or appreciated by the surgeon who believed that a successful surgeon must be a "minute man." Cushing taught that the advancement of neurosurgery depends on the exactness and care with which the more mechanical portions of surgical technic are carried out, leaving no opportunity for a failure when precision might have prevented it. Yet it was interesting to hear of the horror and skepticism with which he viewed the operations performed by Halsted when he first went to Johns Hopkins from his internship. He had been accustomed to see an amputation of the breast performed in twenty-eight minutes by the clock, and a lengthy period of anesthesia was looked on as an almost insurmountable obstacle to recovery. He looked with misgivings on the instructions to leave an operative wound alone for several days before it was dressed, and the use of silk sutures and ligatures was entirely beyond his experience. But to Cushing, preeminently of Halsted's pupils, must go the credit for adopting a technic which he learned to be scientifically correct and for spreading its gospel throughout the surgical world. One has only to look at the record of his operative statistics in a field in which he was pioneering to be convinced of the soundness of his practice.

Born in the Midwest, in a part of the original Northwest territory, and one of a succession of physicians, he lived the greater part of his life in the East, but his interest in surgical happenings beyond the Alleghenies was genuine and sustained. He had an enthusiastic curiosity for the "feel" of a city or an institution which he was visiting. His companions were plied with questions, often embarrassing, as they dis-

played the native son's ignorance of matters about which he should have known. In the end both profited; the one by adding to his store of knowledge, the other by having his interest stimulated in a subject which until then had been wholly unexplored.

Cushing's many contributions to literature are evidence of his masterful and individualistic style of writing. As with all great authors, his literary efforts were attended by considerable agonizing until the final form represented perfection as nearly as he could reach it. Whether in the operating room, on the tennis court, in the preparation of a paper or in the presentation of a subject before a medical meeting, Cushing was exacting of his young associates. Often it was difficult for the younger men to look on these disciplinary measures as anything but sheer mental or physical cruelty, but when, years later, they received a short note saying, "More power to your elbow. H. C.," understanding came. His love for books was encouraged by Osler, and he in turn used the contents of his own library to arouse the interest of a prospective bibliophile. Old books, as unexpected gifts, often sowed a seed in the recipient and thus brought to Cushing a harvest of delight.

It is always difficult to realize that such a dynamic personality has passed. During his lifetime, at home and abroad, he received innumerable tributes to his genius with what at times seemed to be a studied indifference. But there were always words of appreciation for even the simplest of these recognitions of his achievements at the right moment. Eventually the surgical world will come to know him as a great physician, and, for himself, Dr. Cushing would have considered that the highest praise.

Loyal Davis, M.D.

Notices

SPECIAL ISSUE IN HONOR OF DR. DEAN LEWIS

Preparations are being made for a special number of the ARCHIVES OF SURGERY in honor of the sixty-fifth birthday of Dr. Dean Lewis, who has been the Chief Editor of the periodical since its publication was begun. While it is impossible to give a definite date of publication, since the material is not yet in the hands of the publisher, the issue may be expected to appear in the next volume.

INDEX TO VOLUME 39

Obituaries are grouped together and are indexed under that heading in alphabetical order under the letter O.

Abdomen: See also Peritoneum; etc.
abdominal purpura, 914
intra-abdominal pressure; critical review and experimental study, 1006
pain, associated with infection of respiratory tract, 912
pain; enterospasm, 911
surgical aspects of acute abdominal disease in infancy and in childhood, 901
Abnormalities and Deformities: See also under names of diseases, organs and regions, as Arachnodactylia; Breast; Corpus Callosum; Hip Joint; Kidneys; etc.
congenital deformities, 489
plastic surgery of children, 501
Abscess: See also under names of organs and regions, as Prostate; etc.
perinephritic, 155, 178
psoas abscess, 178
Acid, Hydrochloric: See under Fractures
Acidosis with cyclic vomiting, 913
Acromioclavicular Joint: See under Shoulder
Adenitis: See Lymph Nodes
Adenoma, hyperfunctioning, of ectopic parathyroid gland; report of case, 205
of small intestine, 649
renal tumors, 845
Adolescence, epiphysiolysis in, 490
treatment of essential coxa vara of adolescents, 490
Adrenals, tumors, 855
Air Therapy: See under Burns
Alcoholism, concealed chronic alcoholism in surgical patients, 57
Allergy: See Anaphylaxis and Allergy
Amputation-Stumps, amputation neuroma of digital (finger) nerves, 1055
Anaphylaxis and Allergy, intermittent hydrarthrosis, 1053
Androgens, hormone therapy, 886
Therapy: See Prostate, diseases
Andrus, W. D.: Lipid amino nitrogen content of blood in diseases of liver and of biliary tract, 3
Anesthesia, 316
capillary permeability and inflammation in narcotized rabbits, 586
concentration of procaine in spinal fluid of human being after subarachnoid injection; second report, 97
effect on localization of trypan blue in areas of inflammation produced by xylene, 587
removal of procaine from spinal fluid during anesthesia, 682
respiratory physiologic phenomena during inhalation anesthesia, 1001
spinal, circulation during, 429
Anesthetics: See Anesthesia
Aneurysm, diagnosis of ruptured abdominal aortic aneurysm; report of case, 171
of splenic artery; report of case and review of literature, 190
renal, 159
Ankle: See also Astragalus; Foot
treatment of fractures, 508
Anomalies: See Abnormalities and Deformities; and under names of diseases, organs and regions, as Arachnodactylia; Breast; Corpus Callosum; Hip Joint; Kidneys; etc.
Aorta, Aneurysm: See Aneurysm
Apparatus, simple standard apparatus for treatment of compound fractures of hand, fingers and wrists; report of case and evaluation of end results, 214
Appendicitis: See also Abdomen; Appendix
age incidence and mortality, 903
and mesenteric adenitis, 912
correlation of pathologic and clinical observations in chronic lymphoid appendicitis, 577
cyclic vomiting with acidosis, 913
differentiation from pneumonia in children, 914
difficulty of diagnosis, 905
factors in mortality, 910
pyelitis and cystitis, 913
treatment, 909
with reference to pathogenesis, bacteriology and healing, 362
Appendix, appendical stump; its manner of healing in open and in closed method of treatment, 1016
rapidity of advance toward perforation, 906
Arachnodactylia, muscular and skeletal changes in, 741
Arms: See also Extremities; Humerus; etc.
traction-abduction for fractures of, 1055
Arnheim, E.: Scoliosis following empyema, 798
Arp, C. R.: Partial thoracoplasty without deformation, 353
Arteries: See also Aneurysm; Blood pressure; Embolism; etc.
splenic; aneurysm of splenic artery; report of case and review of literature, 190
Arthritis: See also Osteoarthritis
menopausal arthralgia, 493
Arthroplasty: See Hip Joint
Astragalus: See also Ankle
fractures and fracture-dislocation of, 1059
Atrophy: See under Hand; etc.
Avent, C. H.: Primary isolated lymphogranulomatosis (Hodgkin's disease) of stomach; report of case, 423
Avitaminosis: See under Vitamins
Azotemia: See under Blood

Bacilli: See Bacteria
Backache, lumbosacral anomalies and pain low in back, 493
pain low in back and spina bifida occulta, 1053
surgical treatment of pain low in back, 494
Bacteria: See also Staphylococci; Streptococci; etc.
coli; peritonitis in cats produced by intraperitoneal injection of Bacillus coli suspended in mucin, 783
pyarthrosis due to Bacillus haemophilus influenza and Corynebacterium xerosis, 493
Bailey, G.: Seventieth report of progress in orthopedic surgery, 1049
Sixty-ninth report of progress in orthopedic surgery, 489
Barker, V. L.: Hyperfunctioning adenoma of ectopic parathyroid gland; report of case, 205
Bartholin's Gland, tumor, 883
Bastianelli, R.: Charles H. and William J. Mayo, 897
Batts, M., Jr.: Multiple myeloma; review of 40 cases, 807
Beck, C.: Warm moist air therapy for burns, 686
Beck, W. C.: Morbidity caused by operative complications, 478

Benz, E. W.: Nerve action potentials in experimental traumatic shock, 720
Bile Ducts: See also Biliary Tract; Gallbladder
drainage of common bile duct with resultant extrarenal azotemia, 125
Bilharziasis: See Schistosomiasis
Biliary Tract: See also Bile Ducts; Gallbladder; Liver
lipid amino nitrogen content of blood in diseases of liver and of biliary tract, 3
Binkley, J. S.: Surgical excision of material for biopsy in lymphomatous diseases, 728
Biopsy, surgical excision of material for biopsy in lymphomatous diseases, 728
Birth Injuries: See under Paralysis
Bisgard, J. D.: Transplanted epiphysial cartilage, 1028
Bishop, W. A., Jr.: Calcification of supraspinatus tendon; cause, pathologic picture and relation to scalenus anticus syndrome, 231
Bladder: See also Urinary Tract
calculi, 863
cystostomy, 865
incomplete emptying, 867
pyelitis, cystitis and appendicitis, 913
stenosis of vesical neck, 864
sympathectomy, 866
transurethral operation, 866
tumors of, 164, 860
Blood circulation during spinal anesthesia, 429
drainage of common bile duct with resultant extrarenal azotemia, 125
lipid amino nitrogen content of blood in diseases of liver and of biliary tract, 3
pressure and massage in cases of prostatic infection, 874
pressure, high, and adrenal tumors, 855
pressure, high; hypertension and kidney diseases, 853
studies in cross circulation, 959
Bones: See also under names of bones
Diseases: See Osteochondritis; Osteomyelitis; etc.
effects of estrogen on bones, joints and ligaments of castrated guinea pigs, 992
fragility; fracture healing in osteopsathyrosis idiopathica, 1051
fragility; osteopsathyrosis, 489
multiple myeloma; review of 40 cases, 807
muscular and skeletal changes in arachnodactyly, 741
nutritional disturbances of, 1051
osseous changes associated with lymphogranuloma venereum, 108
primary liposarcoma, 496
primary reticulum cell sarcoma of, 496
pulmonary tuberculosis with tuberculosis of bones and joints, 1052
regeneration, 509
sarcoma, 497
sarcoma, experimental, 1062
Bowers, W. F.: Appendicitis with reference to pathogenesis, bacteriology and healing, 362
Brachial Plexus, pressure on, 498
Brain: See also Corpus Callosum; Thalamus; etc.
migraine caused by demonstrable pathologic conditions; report of case with cure by removal of small tumor in calcarine fissure, 104
production of experimental tumors with Shope rabbit papilloma II, 1041
roentgenography; frontal puncture for ventriculography, 122
roentgenography; partial agenesis of corpus callosum; diagnosis by ventriculographic examination, 667
roentgenography; tumors of thalamus; ventriculographic entity, 792
Breast, supernumerary, 926
Brines, O. A.: Hyperfunctioning adenoma of ectopic parathyroid gland; report of case, 203
Burns, warm moist air therapy for, 686
Bursa, subacromial bursitis, 500
synovial sarcomas in bursae and tendon sheaths, 1054

Calcification: See also under Cartilage; Muscles periarticular, of shoulder, 501
Calculi: See Bladder, calculi; Gallbladder, calculi; Kidneys, calculi; Ureters, calculi; Urinary Tract, calculi; etc.
Cancer: See also Sarcoma; Tumors; and under names of organs and regions, as Prostate; Urethra; etc.
multiple primary tumors, 889
of small intestine, 648
Capillaries, permeability and inflammation in narcotized rabbits, 586
Carcinoid: See under Intestines
Carcinoma: See Cancer
Carpus: See Wrist
Carter, R. F.: Etiology of gallstones; critical survey of literature and study of applicability of various theories in 239 operative cases, 691
Cartilage: See also Joints; Osteochondritis; etc.
causal significance to traumatic ossification of fibrocartilage in tendon insertions, 824
hyaline, calcification of, 510
joint cartilage under infraphysiologic, ultraphysiologic and euphysiologic demands, 596
transplanted epiphysial cartilage, 1028
Casberg, M. A.: Acute pancreatic necrosis and acute interstitial pancreatitis; treatment without operation; clinical study of 10 cases, 247
Cass, A. B.: Partial agenesis of corpus callosum; diagnosis by ventriculographic examination, 667
Castration, effects of estrogen on bones, joints and ligaments of castrated guinea pigs, 992
Catheterization: See Urethra
Cerebrospinal Fluid, concentration of procaine in spinal fluid of human being after subarachnoid injection; second report, 97
removal of procaine from spinal fluid during anesthesia, 682
Chobot, G.: Effect of sclerosing substances on healing of fractures, 264
Chodoff, R. J.: Diagnosis of ruptured abdominal aortic aneurysm; report of case, 171
Chondroepiphysitis: See Epiphyses, inflammation; Osteochondritis
Citrates, Therapy: See Rickets
Coccidioides; coccidioidal osteomyelitis, 1053
Cohn, L. C.: Changing experiences with benign and malignant lesions of colon and of rectum, 282
Cohn, S.: Tumors of small intestine, 647
Cole, W. H.: Laryngeal spasm and so-called tracheal collapse; experimental and clinical studies, 10
Coller, F. A.: Reactions of peritoneum to trauma and infection; further experimental studies, 761
Colles Fracture: See Radius, fractures
Colloff, B.: Primary carcinoma of male urethra, 513
Colon: See also Intestines
changing experiences with benign and malignant lesions of colon and of rectum, 282
hemangioma of; report of case, 987
volvulus of pelvic colon, 177
Colonna, P. C.: Embryology of hip joint; preliminary observations, 448
Contractures, Dupuytren's, 1055
Corpus Callosum, partial agenesis of; diagnosis by ventriculographic examination, 667
Coxa Vara: See Hip Joint, deformities
Cranium, sunray hemangioma of skull; report of case, 269
Cressman, R. D.: Capillary permeability and inflammation in narcotized rabbits, 586
Nerve action potentials in experimental traumatic shock, 720

Cuneiform Bone: See Foot; Tarsus
Cystitis: See Bladder
Cystostomy: See under Bladder
Cysts: See also under names of organs and regions, as Kidneys; Urachus; etc.
fate of buried skin grafts in man, 131
Rathke's: See under Pituitary Body

Davis, H. A.: Thyrotoxicosis with malignant neoplasms of thyroid gland; clinicopathologic study, 435
Davis, H. H.: Surgical aspects of acute abdominal disease in infancy and in childhood, 901
Dean, G. O.: Treatment of varicose veins, 711
de Cholnoky, T.: Supernumerary breast, 926
Deformities: See Abnormalities and Deformities; and under names of diseases, organs and regions, as Arachnodactylia; Breast; Corpus Callosum; Hip Joint; Kidneys; etc.
Delli Bovi, E. J.: Thyroid gland; clinical pathologic study with reference to true tumor; analysis of 216 cases, 624
De Santo, D. A.: Embryology of hip joint; preliminary observations, 448
Diabetes Mellitus, peripheral vascular status of 100 unselected patients with diabetes, 86
Dulin, J. W.: Treatment of varicose veins, 711
Duodenum, Ulcers: See Peptic Ulcer
Dupuytren Contracture: See Contractures

Editorials:

Archives of Surgery, new editorial developments, 1

Ehrlich, W.: Frontal puncture for ventriculography, 122
Elliston, W. A.: Seventieth report of progress in orthopedic surgery, 1049
Sixty-ninth report of progress in orthopedic surgery, 489
Embolism, traumatic fat embolism; report of 2 cases with recovery, 182
Empyema, scoliosis following, 798
Endocrine Therapy: See Prostate, diseases
Endometrium, vesical tumor and endometriosis, 860
Enuresis: See Urination, incontinence
Epiphyses, epiphysiolysis in adolescence, 490
inflammation; endocrine implication of juvenile chondroepiphysitis, 1051
posterior dislocation of lower femoral epiphysis, 1058
transplanted epiphysial cartilage, 1028
Estrogens, effects on bones, joints and ligaments of castrated guinea pigs, 992
menopausal arthralgia, 493
Ewing Sarcoma: See Sarcoma
Extremities: See also Arms; etc.
blood supply; peripheral circulatory disturbances in development of osteoarthritis, 1063
blood supply; peripheral vascular status of 100 unselected patients with diabetes, 86
tendon transplantation in upper extremity, 1060

Fahey, J. J.: Muscular and skeletal changes in arachnodactyly, 741
Fascia: See also Contractures, Dupuytren's
ox fascia grafts in tendon defects, 508
Fat, Embolism: See under Embolism
necrosis, 883
Fausset, C. B.: Correlation of pathologic and clinical observations in chronic lymphoid appendicitis, 577
Femur: See also Hip Joint
aseptic necrosis of femoral head following traumatic dislocation; report of 2 cases, 637
Epiphyses: See Epiphyses
fractures of neck of femur, 507
insufficiency fractures of femur and tibia, 1058
Femur—Continued
overgrowth of femoral shaft following fractures in childhood, 1057
role of 3-flanged nail as foreign body, 1063
treatment of fractures of neck of femur, 1057
Fever Therapy: See under Gonorrhea
Fibroma of small intestine, 650
Fingers and Toes: See also Foot; Hand
amputation neuroma of digital (finger) nerves, 1055
Contractures: See under Contractures
simple standard apparatus for treatment of compound fractures of hand, fingers and wrists; report of case and evaluation of end results, 214
Fistula, nephrobronchial, 854
Flatfoot: See Foot, flat
Foot: See also Ankle; Astragalus; Fingers and Toes; Metatarsus; etc.
arches of, 498
flat; Hoke operation for flatfoot, 503
Foreign Bodies, role of 3-flanged nail as, 1063
Foster, A. K., Jr.: Concealed chronic alcoholism in surgical patients, 57
Simple standard apparatus for treatment of compound fractures of hand, fingers and wrists; report of case and evaluation of end results, 214
Fractures: See also Ankle; Arms; Bones, fragility; and under names of bones, as Astragalus; Femur; Humerus; Tibia; etc.
and pregnancy, 1060
Colles: See Radius, fractures
effect of sclerosing substances on healing, 264
healing in osteopsathyrosis idiopathica, 1051
simple standard apparatus for treatment of compound fractures of hand, fingers and wrists; report of case and evaluation of end results, 214
use of hydrochloric acid in delayed calcification of, 509
Freiberg, J. A.: Seventieth report of progress in orthopedic surgery, 1049
Sixty-ninth report of progress in orthopedic surgery, 489
Freund, E.: Joint cartilage under infraphysiologic, ultraphysiologic and euphysiologic demands, 596
Osteochondritis dissecans of head of femur; partial idiopathic aseptic necrosis of femoral head, 323
Fuge, W. W.: Aneurysm of splenic artery; report of case and review of literature, 190

Gallbladder: See also Bile Ducts; Biliary Tract
calculi; etiology of gallstones; critical survey of literature and study of applicability of various theories in 239 operative cases, 691
Gallstones: See Gallbladder, calculi
Gangrene, gas, roentgen treatment of, 1055
Gas Gangrene: See Gangrene
Gastric Ulcer: See Peptic Ulcer
Gastrointestinal Tract: See Colon; Intestines; Rectum; Stomach; etc.
Gastrostomy: See under Stomach
Genitourinary Tract: See also Urinary Tract
staphylococcic infections, 302
urologic complications in malignant disease of rectum, 885
Glenn, F.: Pancreaticogastrostomy; experimental transplantation of pancreas into stomach, 530
Goldfarb, W.: Circulation during spinal anesthesia, 429
Gonorrhea, drug (sulfanilamide) and fever therapy, 320
Grafts: See Skin, grafts
Graves, R. W.: Production of experimental tumors of brain with Shope rabbit papilloma II, 1041
Greene, C. H.: Etiology of gallstones; critical survey of literature and study of applicability of various theories in 239 operative cases, 691

Gross, S. W.: Frontal puncture for ventriculography, 122
Growth, osteomyelitis during period of, 491
Gutierrez, R.: Review of urologic surgery, 145, 302, 838

Hand: See also Fingers and Toes
injuries, purposeful splinting of, 499
simple standard apparatus for treatment of compound fractures of hand, fingers and wrists; report of case and evaluation of end results, 214
surgical repair of long disabled hand, 502
swollen atrophic hand, 499
Hansmann, G. H.: Intra-abdominal hernia; report of case and review of literature, 973
Hemangioma, epidural, associated with hemangioma of vertebrae; report of case, 942
intussusception due to hemangioma of jejunum, 1031
of colon; report of case, 987
of joints, 1054
of small intestine, 650
sunray hemangioma of skull; report of case, 269
Hemostasis, 322
hemostatic effect of vitamin P in different urologic conditions, 322
Hepler, A. B.: Review of urologic surgery, 145, 302, 838
Hernia, intra-abdominal; report of case and review of literature, 973
Hinman, F.: Review of urologic surgery, 145, 302, 838
Hinshaw, H. C.: Sulfapyridine in treatment of pneumonia with reference to postoperative pneumonia, 275
Hip Joint: See also Femur
arthrography in congenital dislocation, 1049
arthroplasty of, 1061
aseptic necrosis of femoral head following traumatic dislocation; report of 2 cases, 637
deformities; treatment of essential coxa vara of adolescents, 490
early diagnosis of congenital dislocation, 1049
embryology of; preliminary observations, 448
osteochondritis dissecans of head of femur; partial idiopathic aseptic necrosis of femoral head, 323
skeletal traction as preliminary procedure for congenital dislocation, 1050
Hirsch, E. F.: Causal significance to traumatic ossification of fibrocartilage in tendon insertions, 824
Hodgkin's Disease: See Lymphogranuloma
Hoke Operation: See Foot, flat
Hotz, R.: Etiology of gallstones; critical survey of literature and study of applicability of various theories in 239 operative cases, 691
Humerus; humeral varus, 489
neurologic lesions in recent fractures of lower end, 505
transcondylar fractures in childhood, 504
Hydatid of Morgagni: See Testicles
Hydrarthrosis, intermittent, 1053
Hydronephrosis, 156, 850
Hyndman, O. R.: Migraine caused by demonstrable pathologic conditions; report of case with cure by removal of small tumor in calcarine fissure, 104
Tumor of thalamus; ventriculographic entity, 792
Hyperalgesia: See Hyperesthesia
Hyperesthesia, tender points in diseases of renal pelvis and of ureter; peripheral distribution of unilateral and bilateral hyperalgesia and anatomic relations of spinal nerves and muscles involved, 457
Hyperparathyroidism: See Parathyroid
Hypertension: See Blood pressure, high
Hypertrophy: See Prostate; Testicles; etc.

Ilfeld, F. E.: Seventieth report of progress in orthopedic surgery, 1049
Sixty-ninth report of progress in orthopedic surgery, 489
Inflammation, capillary permeability and inflammation in narcotized rabbits, 586
effect of anesthesia on localization of trypan blue in areas of inflammation produced by xylene, 587
Influenza, pyarthrosis due to Bacillus haemophilus influenza and Corynebacterium xerosis, 493
Instruments: See Apparatus
Intestines: See also Colon; Rectum; etc.
acute obstruction, 178
carcinoid, or argentaffin tumor, 651
intussusception due to hemangioma of jejunum, 1031
tumors of small intestine, 647
Ulcers: See Peptic Ulcer
Intussusception, 916
due to hemangioma of jejunum, 1031
Iselin, M.: Partial thoracoplasty without deformation, 353

Jejunum: See Intestines
Ulcers: See Peptic Ulcer
Joints: See also under names of individual joints, as Hip Joint; etc.
diseases; pyarthrosis due to Bacillus haemophilus influenza and Corynebacterium xerosis, 493
effects of estrogen on bones, joints and ligaments of castrated guinea pigs, 992
joint cartilage under infraphysiologic, ultraphysiologic and euphysiologic demands, 596
pulmonary tuberculosis with tuberculosis of bones and joints, 1052
Joplin, R. J.: Seventieth report of progress in orthopedic surgery, 1049
Sixty-ninth report of progress in orthopedic surgery, 489

Kandel, A.: Peripheral vascular status of 100 unselected patients with diabetes, 86
Kanzer, M.: Sunray hemangioma of skull; report of case, 269
Kaplan, A.: Sunray hemangioma of skull; report of case, 269
Karshner, R. G.: Epidural hemangioma associated with hemangioma of vertebrae; report of case, 942
Kernohan, J. W.: Tumor of hypophysial duct (Rathke's cysts); report of 11 consecutive cases, 28
Kidneys: See also Urinary Tract
anomalies, 145, 839
calculi, 841
cysts, 157
cysts, hemorrhagic, 847
decapsulation, 854
Diseases: See also Hydronephrosis; Nephritis; Pyelitis; Pyelonephritis
diseases, and hypertension, 853
diseases; tender points in diseases of renal pelvis and of ureter; peripheral distribution of unilateral and bilateral hyperalgesia and anatomic relations of spinal nerves and muscles involved, 457
Fistula: See Fistula
function, 159
nephrostomy, 839
papillary necrosis, 160
parenchymal infection, 851
surgical technic, 838
tuberculosis, 154, 843
tumors, 149, 845
Kleinberg, S.: Aseptic necrosis of femoral head following traumatic dislocation; report of 2 cases, 637
Knee, chronic synovitis treated by synovectomy, 502
hemangioma of joints, 1054

Knee—Continued
repair of anterior cruciate ligament of knee, 1062
roentgen appearance of ligaments of, 510
roentgen diagnosis of destructive lesions of, 510
Koster, H.: Circulation during spinal anesthesia, 429
Concentration of procaine in cerebrospinal fluid of human being after subarachnoid injection; second report, 97
Removal of procaine from cerebrospinal fluid during anesthesia, 682
Kreutzmann, H. A. R.: Primary carcinoma of male urethra, 513
Kross, I.: Appendical stump; its manner of healing in open and in closed method of treatment, 1016
Kuhns, J. G.: Seventieth report of progress in orthopedic surgery, 1049
Sixty-ninth report of progress in orthopedic surgery, 489
Kyphosis: See Spine, curvature

Labor, posterior dislocation of lower femoral epiphysis in breech delivery, 1058
Lam, C. R.: Intra-abdominal pressure; critical review and experimental study, 1006
Lamont, A.: Studies in cross circulation, 959
Landy, J. A.: Tumors of small intestine, 647
Larynx, laryngeal spasm and so-called tracheal collapse; experimental and clinical studies, 10
Leiomyoma of prostate, 873
of small intestine, 650
Lemmer, K. E.: Drainage of common bile duct with resultant extrarenal azotemia, 125
Levitas, M. S.: Tender points in diseases of renal pelvis and of ureter; peripheral distribution of unilateral and bilateral hyperalgesia and anatomic relations of spinal nerves and muscles involved, 457
Lewis, Dean, special issue in honor of, 1068
von Lichtenberg, A.: Review of urologic surgery, 145, 302, 838
Ligaments: See also under Knee
effects of estrogen on bones, joints and ligaments of castrated guinea pigs, 992
Lipoma of small intestine, 650
Liposarcoma, primary, 496
Lipshutz, B.: Diagnosis of ruptured abdominal aortic aneurysm; report of case, 171
Lisfranc's Joint: See Metatarsus; Tarsus
Lithiasis: See Gallbladder, calculi; Kidneys, calculi; Urinary Tract; etc.
Liver: See also Biliary Tract
hepatic function and uremia, 885
lipid amino nitrogen content of blood in diseases of liver and of biliary tract, 3
Logan, M.: Osseous changes associated with lymphogranuloma venereum, 108
Love, J. G.: Tumor of hypophysial duct (Rathke's cysts); report of 11 consecutive cases, 28
Lungs, Tuberculosis: See Tuberculosis, pulmonary
Lymph Nodes: See also Lymphogranuloma
mesenteric adenitis and appendicitis, 912
surgical excision of material for biopsy in lymphomatous diseases, 728
Lymphadenitis: See Lymph Nodes
Lymphogranuloma, primary isolated lymphogranulomatosis (Hodgkin's disease) of stomach; report of case, 423
Lymphogranuloma Venereum, osseous changes associated with, 108
Lymphoma, surgical excision of material for biopsy in lymphomatous diseases, 728

Machemer, W. L.: Aneurysm of splenic artery; report of case and review of literature, 190
McLaughlin, C. W., Jr.: Surgical aspects of acute abdominal disease in infancy and in childhood, 901
Malec, J. P.: Drainage of common bile duct with resultant extrarenal azotemia, 125
Mammary Gland: See Breast
Margolick, M.: Removal of procaine from cerebrospinal fluid during anesthesia, 682
Massage and blood pressure in cases of prostatic infection, 874
Menopause, menopausal arthralgia, 493
Merchant, F. T.: Intussusception due to hemangioma of jejunum, 1031
Mercurochrome, Therapy: See under Pyelonephritis
Mesentery, Lymph Nodes: See Lymph Nodes
mesenteric vascular occlusion, 177
Metatarsus: See also Foot
dislocation of Lisfranc's joint, 1059
Metcalf, W.: Studies in cross circulation, 959
Migraine caused by demonstrable pathologic conditions; report of case with cure by removal of small tumor in calcarine fissure, 104
Milgram, J. E.: Seventieth report of progress in orthopedic surgery, 1049
Sixty-ninth report of progress in orthopedic surgery, 489
Moersch, H. J.: Sulfapyridine in treatment of pneumonia with reference to postoperative pneumonia, 275
Moore, R. A.: Lipid amino nitrogen content of blood in diseases of liver and of biliary tract, 3
Morbidity: See Vital Statistics
Morgan, R. H.: Causal significance to traumatic ossification of fibrocartilage in tendon insertions, 824
Morton, S. A.: Intra-abdominal hernia; report of case and review of literature, 973
Muscles, calcification of supraspinatus tendon; cause, pathologic picture and relation to scalenus anticus syndrome, 231
muscular and skeletal changes in arachnodactyly, 741
paravertebral aspiration of tuberculous abscess of psoas muscle, 1052
pressure on brachial plexus, 498
psoas abscess, 178
restoration of muscle balance in treatment of obstetric paralysis, 503
tender points in diseases of renal pelvis and of ureter; peripheral distribution of unilateral and bilateral hyperalgesia and anatomic relations of spinal nerves and muscles involved, 457
Myeloma, multiple; review of 40 cases, 807

Narat, J. K.: Effect of sclerosing substances on healing of fractures, 264
Navicular Bone: See Scaphoid Bone, Carpal
Nephritis: See also Kidneys, diseases; Pyelonephritic; Uremia
glomerular; urologic diagnosis, 315
Nephrostomy: See Kidneys
Nerves: See also Paralysis
amputation neuroma of digital (finger) nerves, 1055
nerve action potentials in experimental traumatic shock, 720
tender points in diseases of renal pelvis and of ureter; peripheral distribution of unilateral and bilateral hyperalgesia and anatomic relations of spinal nerves and muscles involved, 457
Nervous System: See Brain; Nerves; Spinal Cord; etc.
Neuroma, amputation neuroma of digital (finger) nerves, 1055
Nipple: See Breast

Obituaries:

Cushing, Harvey, 1064
Mayo, Charles H., 897
Mayo, William J., 897

O'Conor, V. J.: Review of urologic surgery, 145, 302, 838
Orthopedic surgery, seventieth report of progress in, 1049
sixty-ninth report of progress in, 489
Ossification, causal significance to traumatic ossification of fibrocartilage in tendon insertions, 824
Osteoarthritis, peripheral circulatory disturbances in development of, 1063
Osteochondritis dissecans of head of femur; partial idiopathic aseptic necrosis of femoral head, 323
endocrine implication of juvenile chondroepiphysitis, 1051
of tarsal navicular bone, 499
Osteogenesis Imperfecta: See Bones, fragility
Osteomyelitis, acute hematogenous, 491
acute, in adults, 492
coccidioidal, 1053
during period of growth, 491
Osteoporosis: See Bones, fragility
Osteopsathyrosis: See Bones, fragility

Pancreas, acute pancreatic necrosis and acute interstitial pancreatitis; treatment without operation; clinical study of 10 cases, 247
acute pancreatitis, 177
pancreaticogastrostomy; experimental transplantation of pancreas into stomach, 530
Pancreaticogastrostomy, experimental transplantation of pancreas into stomach, 530
Papilloma, production of experimental tumors of brain with Shope rabbit papilloma II, 1041
Paralysis, neurologic lesions in recent fractures of lower end of humerus, 505
obstetric, restoration of muscle balance in treatment of, 503
spastic, surgical treatment of, 1062
Parathyroid, hyperfunctioning adenoma of ectopic parathyroid gland; report of case, 205
hyperparathyroidism and urologic conditions, 884
Pearl, F. L.: Peripheral vascular status of 100 unselected patients with diabetes, 86
Peer, L. A.: Fate of buried skin grafts in man, 131
Peptic Ulcer, ruptured, 175
Peritoneum, reactions to trauma and infection: further experimental studies, 761
Peritonitis in cats produced by intraperitoneal injection of Bacillus coli suspended in mucin, 783
pneumococcic and streptococcic, 922
reactions of peritoneum to trauma and infection; further experimental studies, 761
stages in peritonitis based on defense mechanism in relation to treatment, 770
Person, E. C., Jr.: Pancreaticogastrostomy: experimental transplantation of pancreas into stomach, 530
Phalanges: See Fingers and Toes
Photography, Biological Photographic Association, annual convention, 170
Pituitary Body, tumor of hypophysial duct (Rathke's cysts); report of 11 consecutive cases, 28
Plastic Surgery: See Surgery, plastic
Pneumococci and streptococcic peritonitis, 922
Pneumonia, differentiated from acute appendicitis in children, 914
sulfapyridine in treatment with reference to postoperative pneumonia, 275
Pomerantz, L.: Effects of estrogen on bones, joints and ligaments of castrated guinea pigs, 992
Pregnancy and fractures, 1060
Priestley, J. T.: Review of urologic surgery, 145, 302, 838
Prigot, A.: Traumatic subcutaneous rupture of normal spleen, 551
Procaine: See also Anesthesia
concentration in spinal fluid of human being after subarachnoid injection; second report, 97
removal from spinal fluid during anesthesia, 682
Proliferol, Therapy: See under Fractures
Prostate, abscess, 307
cancer, 306
diseases; endocrine therapy [androgen], 309
enlargement, 869
hypertrophy, 308
infarction, 310
massage and blood pressure in cases of prostatic infection, 874
preoperative mortality, 873
sarcoma, 873
tumors, 873
Provisor, B.: Circulation during spinal anesthesia, 429
Puberty: See Adolescence
Purpura, abdominal, 914
Pyarthrosis: See Joints, diseases
Pyelitis, cystitis and appendicitis, 913
Pyelography; urography, 888
Pyelonephritis, 159, 855
mercurochrome in treatment of, 321
Pyuria: See Urinary Tract, infections

Rachitis: See Rickets
Radius, fractures; late rupture of extensor pollicis longus tendon after Colles' fracture, 506
operative treatment of dislocation of head of radius, 1056
Rand, C. W.: Epidural hemangioma associated with hemangioma of vertebrae; report of case, 942
Ransom, H. K.: Reactions of peritoneum to trauma and infection; further experimental studies, 761
Rathke's Pouch: See under Pituitary Body
Rectum, changing experiences with benign and malignant lesions of colon and of rectum, 282
urologic complications in malignant disease of, 885
Reeves, D. L.: Epidural hemangioma associated with hemangioma of vertebrae; report of case, 942
Partial agenesis of corpus callosum; diagnosis by ventriculographic examination, 667
Respiration, respiratory physiologic phenomena during inhalation anesthesia, 1001
Respiratory Tract, infection of, associated with abdominal pain, 912
Rhabdomyosarcoma of prostate, 873
Richter, M.: Tumors of small intestine, 647
Rickets, infantile, citrates in treatment of, 1051
Rife, C. S.: Reactions of peritoneum to trauma and infection; further experimental studies, 761
Rigdon, R. H.: Capillary permeability and inflammation in narcotized rabbits, 586
Risk, R.: Warm moist air therapy for burns, 686
Roberts, S. M.: Seventieth report of progress in orthopedic surgery, 1049
Sixty-ninth report of progress in orthopedic surgery, 489
Roentgen Rays, Therapy: See under names of organs, regions and diseases

Sarcoma: See also Cancer; Liposarcoma; Rhabdomyosarcoma; Tumors
experimental bone sarcoma, 1062
Ewing's, 497
of bone, 497
of prostate, 873
of small intestine, 649
primary reticulum cell sarcoma of bone, 496
synovial, in bursae and tendon sheaths, 1054

Sawyer, C. F.: Hemangioma of colon; report of case, 987
Scaphoid Bone, Carpal; nonunion of carpal navicular bone, 1056
Schistosomiasis; bilharziasis, 168
Scholl, A. J.: Review of urologic surgery, 145, 302, 838
Sclerosing Solutions: See under Fractures
Scoliosis: See Spine, curvature
Scrotum, fat necrosis of, 883
Seley, G. P.: Peritonitis in cats produced by intraperitoneal injection of Bacillus coli suspended in mucin, 783
Selig, S.: Scoliosis following empyema, 798
Shapiro, A.: Concentration of procaine in cerebrospinal fluid of human being after subarachnoid injection; second report, 97
Removal of procaine from cerebrospinal fluid during anesthesia, 682
Shelden, C. H.: Tumor of hypophysial duct (Rathke's cysts); report of 11 consecutive cases, 28
Shock, nerve action potentials in experimental traumatic shock, 720
Shoulder: See also Humerus
calcification of supraspinatus tendon; cause, pathologic picture and relation to scalenus anticus syndrome, 231
periarticular calcification of, 501
recurrent dislocation of, 504
subacromial bursitis, 500
Shumacker, H. B., Jr.: Studies in cross circulation, 959
Skin, grafts; fate of buried skin grafts in man, 131
Skull: See Cranium
Smith, S.: Warm moist air therapy for burns, 686
Societies, Biological Photographic Association, annual convention, 170
Congrès français d'urologie, 512
International Congress of European Society of Structive Surgery, 512
Solutions, Sclerosing: See under Fractures
Spina Bifida, pain low in back and spina bifida occulta, 1053
Spinal Cord, epidural hemangioma associated with hemangioma of vertebrae; report of case, 942
Spinal Fluid: See Cerebrospinal Fluid
Spine, curvature; compensation-derotation treatment of scoliosis, 494
curvature; scoliosis following empyema, 798
epidural hemangioma associated with hemangioma of vertebrae; report of case, 942
fracture-dislocation of, 503
growth in length of vertebrae, 1063
lumbosacral anomalies and pain low in back, 493
paravertebral aspiration of tuberculous abscess of psoas muscle, 1052
spondylolisthesis, 493
Spleen, traumatic subcutaneous rupture of normal spleen, 551
Spondylolisthesis: See Spine
Stains and Staining, effect of anesthesia on localization of trypan blue in areas of inflammation produced by xylene, 587
Staphylococci and renal calculi, 841
infections of genital tract, 302
Steinberg, B.: Stages in peritonitis based on defense mechanism in relation to treatment, 770
Stomach, pancreaticogastrostomy; experimental transplantation of pancreas into stomach, 530
primary isolated lymphogranulomatosis (Hodgkin's disease) of stomach; report of case, 423
Ulcers: See Peptic Ulcer
Streptococci; pneumococcic and streptococcic peritonitis, 922
Sulfanilamide and Sulfanilamide Derivatives, Therapy, 889. See also Gonorrhea
Sulfapyridine: See under Pneumonia
Surgery, concealed chronic alcoholism in surgical patients, 57
morbidity caused by operative complications, 478
new editorial developments for Archives of Surgery, 1
plastic, of children, 501
sulfapyridine in treatment of pneumonia with reference to postoperative pneumonia, 275
Sutro, C. J.: Effects of estrogen on bones, joints and ligaments of castrated guinea pigs, 992
Sylnasol, Therapy: See under Fractures
Symposiums, new feature of Archives for 1940, 896
Synovial Membrane, chronic synovitis treated by synovectomy, 502
synovial sarcomas in bursae and tendon sheaths, 1054
Syphilis: See under names of organs and regions

Talus: See Astragalus
Tarsus: See also Ankle; Astragalus; Foot; Scaphoid Bone, Tarsal
dislocation of Lisfranc's joint, 1059
osteochondritis of tarsal navicular bone, 499
Tendons, causal significance to traumatic ossification of fibrocartilage in tendon insertions, 824
end results of tendon suture of arm and hand, 1060
late rupture of extensor pollicis longus tendon after Colles' fracture, 506
ox fascia grafts in tendon defects, 508
supraspinatus, calcification of; cause, pathologic picture and relation to scalenus anticus syndrome, 231
synovial sarcomas in bursae and tendon sheaths, 1054
transplantation in upper extremity, 1060
Testicles, ectopic testes, 310, 880
hypertrophy, 312
torsion of appendix testis, 882
torsion of pedicle of hydatid of Morgagni, 881
tumors, 311, 875
Thalamus, tumors of; ventriculographic entity, 792
Thompson, G. J.: Review of urologic surgery, 145, 302, 838
Thoracoplasty: See Thorax, surgery
Thorax, surgery; partial thoracoplasty without deformation, 353
Thyroid: See also Parathyroid
clinical pathologic study with reference to true tumor; analysis of 216 cases, 624
endocrine implication of juvenile chondroepiphysitis, 1051
laryngeal spasm and so-called tracheal collapse (during thyroidectomy); experimental and clinical studies, 10
thyrotoxicosis with malignant neoplasms of thyroid gland; clinicopathologic study, 435
Thyroidectomy: See under Thyroid
Thyrotoxicosis: See under Thyroid
Tibia, effect of sclerosing substances on healing of fractures, 264
insufficiency fractures of femur and tibia, 1058
operative treatment of avulsion fractures of eminentia intercondyloidea, 1059
Toes: See Fingers and Toes
Trachea, laryngeal spasm and so-called tracheal collapse; experimental and clinical studies, 10
Transplantation: See Skin, grafts; Tendons; Ureters
Trochanter: See Femur

Trauma, nerve action potentials in experimental traumatic shock, 720
traumatic fat embolism; report of 2 cases with recovery, 182
traumatic subcutaneous rupture of normal spleen, 551
Trypan Blue: See Stains and Staining
Tuberculosis: See also under Bones; Kidneys; etc.
pulmonary, with tuberculosis of bones and joints, 1052
Tumors: See also Adenoma; Cancer; Fibroma; Hemangioma; Leiomyoma; Papilloma; Sarcoma; etc.; and under names of organs and regions, as Adrenals; Bartholin's Gland; Bladder; Brain; Intestines; Kidneys; Prostate; Testicles; Ureters; etc.
rare, of small intestine, 651
Tuohy, E. B.: Respiratory physiologic phenomena during inhalation anesthesia, 1001
Twiss, J. R.: Etiology of gallstones; critical survey of literature and study of applicability of various theories in 239 operative cases, 691

Urachus, cysts, 868
Uremia: See also Nephritis
and hepatic function, 885
Ureterocele: See Ureters, dilatation
Ureters: See also Urinary Tract
calculi, 160, 177
dilatation, 858
inflammation, 857
tender points in diseases of renal pelvis and of ureter; peripheral distribution of unilateral and bilateral hyperalgesia and anatomic relations of spinal nerves and muscles involved, 457
transplantations, 162, 859
tumor, 161
Urethra, catheterization, 305
primary carcinoma of male urethra, 513
staphylococcic infections of, 302
Urinary Tract: See also Genitourinary Tract; Kidneys; Ureters; etc.
calculi, 313
calculi, chemical composition of, 315
hemostatic effect of vitamin P in different urologic conditions, 322
hyperparathyroidism and urologic conditions, 884
Urinary Tract—Continued
infections, 887
infections, sulfanilamide therapy, 889
urinary extravasation, 318
urinary lithiasis, 888
urologic diagnosis, 315
Urination, incontinence, 165
Urography: See Pyelography
Urolithiasis: See Urinary Tract, calculi
Urologic surgery, review of, 145, 302, 838

Vagina, inflammation; vaginitis, 322
van Epps, C.: Tumor of thalamus; ventriculographic entity, 792
Varicose Veins, treatment of, 711
Veins: See Embolism; etc.
Varicose: See Varicose Veins
Ventriculography: See Brain, roentgenography
Vertebrae: See Spine
Vital Statistics, morbidity caused by operative complications, 478
Vitamins, P, hemostatic effect in different urologic conditions, 322
Volvulus: See Colon
Vomiting, cyclic, with acidosis, 913

Warshaw, R.: Concentration of procaine in cerebrospinal fluid of human being after subarachnoid injection; second report, 97
Removal of procaine from cerebrospinal fluid during anesthesia, 682
Whitaker, J. C.: Traumatic fat embolism; report of 2 cases with recovery, 182
Wildbolz, E.: Review of urologic surgery, 145, 302, 838
Woodhall, B.: Production of experimental tumors of brain with Shope rabbit papilloma II, 1041
Wright, L. T.: Osseous changes associated with lymphogranuloma venereum, 108
Traumatic subcutaneous rupture of normal spleen, 551
Wrist, simple standard apparatus for treatment of compound fractures of hand, fingers and wrists; report of case and evaluation of end results, 214

Xylene, effect of anesthesia on localization of trypan blue in areas of inflammation produced by xylene, 587